

JPRS-UPM-86-006

14 March 1986

# USSR Report

PHYSICS AND MATHEMATICS



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## ACOUSTICS

### FINDING THAT X-RAYS CAN CARRY AUDIO INFORMATION

Yerevan SOVETSKAYA KIRGIZIYA in Russian 3 Oct 85 p 3

[Article by Yu. Kankanyan, correspondent (Yerevan)]

[Text] New possibilities for transmitting audio information are opened up by the use of x-rays for this purpose. This has been confirmed by research which was done at the Armenian Academy of Sciences' Institute of Applied Physics Problems.

"The idea that quanta of x-radiation could be carriers of information occurred to us in the course of experiments for controlling x-rays by means of acoustic vibrations," said Doctor of Physical-Mathematical Sciences A. Mkrtchyan, director of the institute. "This was later confirmed experimentally. Gamma quanta were directed at a special device; passing through it, they were exposed to the effects of sound vibrations, which loaded them with certain information. The rays then entered a special receiver which restores this information in the form of speech."

Prospects for the practical application of this communication principle are highly promising. For example, it presents the possibility of transmitting information in the form of narrow-beam radiation that contains huge masses of information and is capable of penetrating opaque media besides.

FTD/SNAP/9835  
CSO: 1862/041

## CRYSTALS, LASER GLASSES AND SEMICONDUCTORS

### METHOD FOR GROWING SAPPHIRE CRYSTALS WITH COMPLEX SHAPES

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian No 169 (4860), 25 Jul 85  
p 4, cols 5-7

[Article by I. Demchenko]

[Excerpt] Specialists of the All-Union Scientific Research Institute of Electrothermal Equipment (VNIETO) can grow crystals with prescribed shapes in only a few hours.

Scientists had known for a long time how to grow synthetic sapphire, but only in its natural shape. Pieces of this crystal had to be ground with diamond tools in order to obtain different kinds of products.

The new artificial-sapphire growing process developed at VNIETO is based on a method proposed by A. Stepanov, corresponding member of the USSR Academy of Sciences, which makes it possible to influence a crystal's geometry while it is growing. Industrial equipment now turns out single-crystal products of the most diverse shapes. And these products need no additional machining.

"The term 'growing crystal' has come to be taken literally," related L. Zatulovskiy, head of a laboratory. "It would be more correct to say that we 'pull' crystals out of melts. This process takes place in a vacuum furnace at a temperature of more than 2,000 degrees.

On a laboratory table, I saw a kind of exhibit of products made of artificial sapphire. Everything imaginable was there: prisms and rods with various cross-sections, sealing pieces, and small crucibles.

These products can be used in metallurgy, electronics, semiconductor technology, the watch and jewelry industry, and optics.

VNIETO is now developing industrial units with which more intricate products can be made. Tubes with cross partitions and spiral heat exchangers that are resistant to chemically active substances have already been made from sapphire in the laboratory.

FTD/SNAP/9835  
CSO: 1862/041

## NEW HIGH RATE CRYSTAL GROWTH TECHNOLOGY FOR LASER OPTICS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 29 May 85 p 4

[Text] A high rate crystal growth technology has been developed at the Institute for Applied Physics of the Academy of Sciences of the USSR for crystals of high optical quality, allowing to control parameters of laser radiation. By usual methods it used to take more than one year to grow a crystal of 15 centimeters in diameter, from which light beam frequency multiplier element can be manufactured. The new method provides a crystal growth rate of up to one millimeter per hour and reduces the crystal growth time to several days.

[Photograph on following page.]



On the photo: Quality testing of a crystal grown by the new technology.  
Photo by TASS.

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CSO: 1862/433

## CONTRIBUTIONS TO PRIZE-WINNING WORK IN OPTOELECTRONICS

Vilnius SOVETSKAYA LITVA in Russian, No 26, 20 Nov 85 p 4

[Excerpt] "Even in the most advanced computer, one performing billions of operations per second," said Doctor of Physical-Mathematical Sciences Remigiyus Baltrameyunas, professor of the chair of semiconductor physics of Vil'nyus University, "the transmitted information is delayed en route. The electrons carrying the current 'lose time' as they pass through the wires and other components. By substituting a laser beam and a laser-sensitive semiconductor crystal for them, it is possible to attain a new level of information processing, and also to reduce the size of the computer substantially. We have reached an understanding of the principles governing the changes in the optical properties of semiconductors into which pulses of a laser beam are passed, and have been able to determine how the electrons behave under its influence. Developers of optoelectronic equipment have thus received a scientific basis for this applied research."

The work of Doctor of Physical-Mathematical Sciences Vitautas Bareykis, head of a laboratory of the Lithuanian Academy of Sciences' Institute of Semiconductor Physics, has also contributed to basic scientific theory and opened up new possibilities in communication transmission and measurement technology. He studied electrical properties of semiconductors and so-called noise. In scientific language, 'noise' means the intrinsic random movement of electrons, which changes under the influence of electric fields and other external factors. It turns out that noise, which greatly interferes with the operation of radio equipment, is a good source of information. It can, for example, tell us much about the internal properties of a material under study, and it helps determine the temperature in highly hazardous environments which conventional measuring instruments cannot tolerate.

Scientists no longer base their experiments on intuition alone. On the basis of complex theoretical mathematical models, they calculate optimum variants of experiments and determine which series will be successful. Numerical modeling of experiments done by Doctor of Physical-Mathematical Sciences Antanas Reklaitis, head of a sector of the Institute of Semiconductor Physics, has become a kind of beacon in the work of the above mentioned scientists.

The cycle of work of physicists R. Baltrameyunas, V. Bareykis and A. Reklaitis has been awarded this year's Lithuanian SSR State Prize. The scientists' research will contribute to the development of new semiconductor instruments of modern microelectronics.

FTD/SNAP/9835  
CSO: 1862/93



## ARMENIAN INSTITUTE'S WORK ON LASER CRYSTALS

Moscow KOMMUNIST in Russian 19 Sep 85 p 2

MUSAYELYAN, V.

[Abstract] The article reports on contributions of the Institute of Physics Research to the advancement of quantum electronics. The Armenian institute is called one of the country's leading centers for crystal physics and laser technology. Its research is said to encompass all stages from the growing of crystals to the development of lasers.

The institute's researchers reportedly are solving problems of developing lasers with high efficiency and of expanding the spectral range of laser radiation. The work involves the laboratories of high-temperature crystallization, solid-state generators, crystal optics, and growth of nonlinear crystals. In particular, researchers are investigating crystals which manifest nonlinear optical properties most strongly. One of them, lithium iodate, reportedly is being used for doubling laser emission frequency, and also for smooth conversion of this frequency. Another crystal with nonlinear properties which researchers are studying is lithium niobate. It is explained that to use this crystal for conversion of laser emission frequency, the scientists must overcome the effect of optical inhomogeneity that is manifested in it. The laboratories of crystal optics and growth of nonlinear crystals reportedly have developed a method for growing this crystal which permits both its structure and its chemical composition to be controlled.

The institute's laboratory of picosecond processes is said to have designed an instrument with a lithium iodate crystal for measuring pulses of picosecond duration. The laboratory is making the instruments, which are said to be superior to all previous ones of this type, and supplying them to scientific organizations.

Other types of laser crystals that are mentioned in the article are yttrium-aluminum garnets and lead molybdate crystals.

FTD/SNAP/9835  
CSO: 1862/041

## PHOTOS OF AWARD RECIPIENTS FOR CRYSTALS FOR OPTICAL ADP SYSTEMS

Leningrad LENINGRADSKAYA PRAVDA in Russian, No 267, 20 Nov 85 p 1

[Abstract] Photographs are given of three Leningrad residents who received the 1985 USSR State Prize for basic research of photorefractive and liquid crystals for optical information-processing systems. They are: Doctor of Physical-Mathematical Sciences Mikhail Petrovich Petrov, deputy director of the USSR Academy of Sciences' Physical-Technical Institute imeni Ioffe; Candidate of Physical-Mathematical Sciences Sergey Ivanovich Stepanov, senior science associate of this institute; and Candidate of Physical-Mathematical Sciences Anatoliy Vasil'yevich Khomenko, also a senior associate of the institute.

FTD/SNAP/9835

CSO: 1862/93

## NEW POSSIBILITIES OF $\text{Cr}^{3+}$ IONS AS ACTIVATOR FOR SOLID STATE LASERS ACTIVE MEDIA

Moscow NOVYYE VOZMOZHNOСТИ IONOV  $\text{Cr}^{3+}$  KAK AKTIVATORA AKTIVNYKH SRED TVERDOTEL'NYKH LAZEROV in Russian 1985 pp 1-17

ZHARIKOV, Ye. V., LAVRISHCHEV, S. V., LAPTEV, V. V., OSTROUMOV, V. G., SAIDOV, Z. S., SMIRNOV, V. A., and SHCHERBAKOV, I. A., Laboratory of Solid State Physics, Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The spectral-luminescent properties of yttrium-scandium-gallium, yttrium-gallium, lanthanum-lutecium-gallium, gadolinite-gallium, and gadolinite-scandium-gallium garnets activated with chromium ions are studied. The relationship between the lifetime of the excited state of chromium and the luminescence intensity ratio in the  ${}^4\text{T}_2$ - ${}^4\text{A}_2$  and  ${}^2\text{B}$ - ${}^4\text{A}_2$  channels and the efficiency of the  $\text{Cr}^{3+}$ -acceptor transition is analyzed. A method is proposed for determining the energy gap between the  ${}^2\text{E}$  and  ${}^4\text{T}_2$  levels of  $\text{Cr}^{3+}$  from the temperature behavior of the efficiency of the non-radiation  $\text{Cr}^{3+}$ -acceptor transfer. By determining the relationship between the size of the energy gap, the lifetime of the excited states of  $\text{Cr}^{3+}$  and the efficiency of the  $\text{Cr}^{3+}$ - $\text{Nd}^{3+}$  energy transfer makes it possible to predict the spectral-luminescent properties of different matrices activated with  $\text{Cr}^{3+}$  ions and co-activated with another dopant (such as  $\text{Nd}^{3+}$  ions), which is of major interest in the search for new materials for quantum electronics. Figures 6; references 19: 11 Russian, 8 Western.  
[438-6900]

INFLUENCE OF EXCESS SULFUR PRESSURE DURING GROWTH OF CdS CRYSTALS ON CHARACTERISTICS OF LASERS EXCITED BY ELECTRON BEAMS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85  
(manuscript received 4 Oct 84; after revision 10 Dec 84) pp 1307-1309

AKIMOVA, I. V., BEREZINA, T. I., PECHENOV, A. N., RESHETOV, V. I.,  
RESHETOVA, L. Ye. and SHALKIN, P. V., Physics Institute imeni P. N. Lebedev,  
USSR Academy of Sciences, Moscow

[Abstract] A study was made of the influence of partial pressure of sulfur  $p_s$  on luminescent characteristics of crystals and parameters of laser screens (LS). The growth rate of crystals remained constant with increasing  $p_s$  up to about 10 mmHg, while further increases in  $p_s$  caused decreasing growth rate, by a factor of 2 at 100 mmHg. Lasers prepared from crystals grown at  $p_s = 0.1-10$  mmHg had higher degradation resistance than lasers grown at  $p_s$  outside this range. Figures 3; references 9: 7 Russian, 2 Western.  
[503-6508]

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## NEW CLASS OF SOLUTIONS TO GAS DYNAMICS WITH SHOCK WAVES PROBLEMS

Moscow PRIKLADNAYA MATEMATIKA I MEKhanika in Russian Vol 49, No 5,  
Sep-Oct 85 (manuscript received 3 Apr 84) pp 752-757

POSLAVSKIY, S. A., Moscow

[Abstract] An exact solution to a system of equations describing one-dimensional flow of an ideal gas is coupled to a shock wave propagating through that gas with zero pressure, assuming this to be a dust gas. Two problems are then formulated accordingly and solved asymptotically for the Euler coordinate  $r = vt + f(v)$  and the density  $\rho = (h(v)/[vt + f(v)]^{v-1}) - [f'(v) + t]$  ( $v$ - velocity,  $t$ - time,  $v = 1, 2, 3$  respectively for plane, cylindrical, and spherical waves), where  $f(v)$  and  $h(v)$  are arbitrary functions generally nonunique and not defined everywhere on the  $v$ -axis. The first task is finding  $f(v_1) = r_*[t(v_1)] - v_1 t(v_1)$  ( $r_*$ - radius of shock wave) for given density and pressure distributions behind the shock wave. The second task is finding the Lagrange coordinate  $\xi_*(t) = r_*/R$  of gas particles at the wavefront ( $R$ - radius of medium) for a given  $f(v)$  and thus given velocity distribution. These are solved by the energy method, considering that a shock wave originates at the center of symmetry upon release of a positive energy at some instant of time. The solution for the special case of an adiabatic exponent  $\gamma = (v + 2)/v > 1$  with Gaussian density and pressure distributions behind the wave front describes collapse of a cavity in a dust cloud with attendant formation of a shock wave. The author thanks I. S. Shikin for suggestions and discussions. References 9: 8 Russian, 1 Western.  
[73-2415]

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FINAL STAGE OF DEGENERACY OF TURBULENT VELOCITY FIELD IN WAKE STREAM

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 49, No 2, Aug 85  
(manuscript received 20 Jul 84) pp 209-214

KOVALEV, I. I., KOLOVANDIN, B. A. and LUCHKO, N. N., Institute of Heat and Mass Transfer imeni A. V. Lykov, BSSR Academy of Sciences, Minsk

[Abstract] Degeneracy of a turbulent velocity is analyzed on the basis of the three-parametric differential model  $q^2 - u_1 u_2 - \epsilon_u$  of wake evolution ( $1/2 q^2$  - kinetic energy of velocity fluctuations,  $u_1, u_2$  - fluctuation components of velocity,  $\epsilon_u$  - rate of dissipation of kinetic turbulence energy) according to O. M. Phillips for the asymptotic case of weak turbulence with  $N_{Re\lambda} \rightarrow 0$  ( $N_{Re\lambda}$  - turbulent Reynolds number,  $\lambda$  - Taylor microturbulence scale). An analytical solution is obtained, assuming that the similarity parameters are self-adjoint functions of both axial and radial coordinates. Calculations according to the method proposed by V. A. Gorodtsov yield a system of ordinary differential equations solvable for the appropriate boundary conditions. The necessary empirical constants, numerical factors and exponents, are obtained with the aid of the invariant Loytsyanskiy relation for plane flow ( $n = 0$ ) and for axisymmetric flow ( $n = 1$ ). In the latter case the solution yields two possible laws of evolution for the defect of average velocity characterizing the decay of turbulence and correspondingly of the turbulent radial velocity profile along the axis. References 6: 2 Russian, 4 Western (1 in Russian translation).  
[593-2415]



## INTERMEDIATE SURFACES AROUND ELLIPSOIDAL SHELL WITH SHORT-WAVE VIBRATIONS IN FLUID

Moscow PRIKLADNAYA MATEMATIKA I MEKhanika in Russian Vol 49, No 5, Sep-Oct 85  
(manuscript received 23 Oct 84) pp 808-814

POPOV, A. L. and CHERNYSHEV, G. N., Moscow

[Abstract] An elastic closed prolate ellipsoidal shell in a boundless compressible fluid and under a normal periodic load is considered, this load inducing short-wave quasi-transverse vibrations. The behavior of such a shell as radiator is analyzed, its performance being determined by the location of intermediate surfaces around it and of intermediate lines on it. The corresponding Helmholtz equation for the pressure field in the fluid is formulated in a system of spheroidal coordinates and solved asymptotically with respect to a large parameter, a large real part of the complex frequency corresponding to short-wave vibrations and allowing segregation of all functions in that equation into two groups. The first group, varying slowly along the meridional coordinate, are Lamé coefficients and radii of the shell curvature. The second group, varying fast along the meridional coordinate, are shell deflection and stresses in the shell as well as pressure in the fluid. The solution simplifies for axisymmetric vibrations, in which case waves are emitted most intensely from surfaces within the polar regions and least intensely from surfaces within the equatorial region. The contrast increases with decreasing vibration frequency and with increasing prolateness of the shell, a more uniform radiation pattern evolving as the vibration frequency rises. These results are confirmed by numerical calculations for a steel shell in water. Figures 1; references: 4 Russian.  
[73-2415]

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## HIGH-TEMPERATURE PHYSICS

### CHANGE IN ELECTROMAGNETIC CHARACTERISTICS OF YTTRIUM-IRON GARNET FILMS AFTER EXPOSURE TO HIGH INTENSITY LASER PLASMA RADIATION

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 55, No 6, Jun 85  
(manuscript received 20 Jun 84) pp 1188-1190

LEONOV, Yu. S., POPKOV, A. F. and RUDYY, Yu. B.

[Abstract] A report is presented on the first experiment performed to study the influence of radiation from a laser plasma at wavelength 0.8-10 nm, pulse length 2 ns, dose 0.25-0.03 J/cm<sup>2</sup>, energy density 15-100 MW/cm<sup>2</sup>, on the attenuation spectrum of surface magnetostatic waves in yttrium-iron garnet films. A laser-plasma radiation source consisting of a plasma created upon focusing of the second harmonic of an Nd laser on the surface of a massive target made of bismuth was used to act upon the YIG film. It was found that although radiation is absorbed primarily in a layer 1 micrometer thick, the change in the width of the FMR line occurs throughout the entire volume. For the entire volume of a film 5.4 micrometers thick the effect is not thermal in nature, since the adiabatic temperature jump for radiation dose 0.1 J/cm<sup>2</sup> is less than 100 K. In the layer in which the radiation is absorbed, the temperature jump is about 400 K. Figure 1; references 6: 4 Russian, 2 Western.  
[497-6508]

UDC: 621.375.82

### DYNAMICS OF CHANGE IN INDEX OF REFRACTION OF K8 GLASS AT HIGH HEATING AND COOLING RATES

Leningrad FIZIKA I KHIMIYA STEKLA in Russian Vol 11, No 3, May-Jun 85  
(manuscript received 28 Jul 83) pp 331-337

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[Abstract] A study is made of the behavior of the refraction index at the melting point over a broad range of temperatures from room temperature to

1600°C for melting occurring either entirely within a specimen of K8 glass or extending to the surface of the specimen, with melting initiated by a millisecond laser pulse. Interferometric studies of glass specimens were performed on an installation in which a continuous argon laser provided measuring radiation directed perpendicularly to the radiation of a neodymium laser focused within the volume or on the surface of the specimen. The electrical vector of the measuring radiation was parallel to the axis of the caustic of the heating beam. The laser beam heated the glass at about  $1.5 \cdot 10^{50} \text{C} \cdot \text{s}^{-1}$ . The values of  $(dn/dT)_{\rho_0}$  and modulus of hydrostatic compression were determined for the liquid glass. Figures 3; references 17: 16 Russian, 1 Western.  
[528-6508]

UDC 535.21-3:621.375.826

# INTERACTION OF HIGH-INTENSITY ULTRAVIOLET LASER RADIATION WITH SOLID SURFACES

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49, No 4, Apr 85 pp 732-737

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[Abstract] The effect of ultraviolet laser radiation on metal surfaces was studied with a high-intensity XeCl\* electric-discharge excimer laser emitting pulses of  $100 \text{ MW/cm}^2$  to  $5 \text{ GW/cm}^2$  intensity and 30 ns duration at the 308 nm wavelength. Plasma formation thresholds had been predicted theoretically, taking into account initiation and buildup of photoionization under electron impact of the second kind and subsequent avalanche breakdown. These thresholds were confirmed experimentally for copper and titanium, while threshold for aluminum was found to be much lower than predicted. The frequency spectrum of these thresholds is accordingly determined on the basis of applicable theoretical relations, in the approximation of a uniform energy spectrum. Microstructural and metallographic examination reveals that purification of the target metal surface raises the plasma formation threshold, while exposure to successive laser pulses lowers it. The plasma layer remains quite transparent, even when the threshold is relatively high, so that efficient thermal action on metal surfaces is feasible over a wide range of laser radiation intensity. This has significant practical implications for use of laser technology in metallurgy. Figures 4; references 14: 6 Russian, 8 Western.  
[417-2415]

## INSTABILITY OF EVAPORATION FRONT DURING ABSORPTION OF LASER RADIATION BY PLASMA

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49, No 4, Apr 85 pp 776-778

AKHSAKHALYAN, A. D., GAPONOV, S. V. and LUCHIN, V. I.

[Abstract] Evaporation of a substance under action of laser pulses in vacuum is analyzed and instability of the evaporation front is attributed to a non-uniform optical thickness of the eroding plasma layer, this conclusion being drawn on the basis of experimental data. Opaque substances were exposed to laser radiation pulses of  $10^8$ - $10^{10}$  W/cm<sup>2</sup> intensity and 25 ns duration at the 1.06  $\mu$ m wavelength. The energy spectrum of ions and atoms was found to have two peaks:  $E_1$ -300 eV and  $E_2$ -30 eV at  $q \cdot 10^9$  W/cm<sup>2</sup> radiation intensity over a surface spot d-1 mm in diameter. Repetitive irradiation of the same target spot was found to produce a surface relief, with a characteristic dimension of 30  $\mu$ m on copper or gold surfaces and 300  $\mu$ m on tungsten surfaces; this surface relief disappeared under incident radiation of intensity higher than  $2 \cdot 10^9$  W/cm<sup>2</sup>. The mean energy at the first peak was found to increase first linearly with increasing incident radiation intensity over the  $3 \cdot 10^8$ - $2 \cdot 10^9$  W/cm<sup>2</sup> range and then sublinearly as the square root of the incident radiation intensity above that range. This suggests that two different processes are at play here, possibly separated in time, such as initial surface shaping and vaporization by laser radiation and subsequent surface or volume vaporization by laser radiation and subsequent surface or volume vaporization by radiation from the plasma layer. It also suggests that a surface relief is produced in two stages, the initial shape by the first series of typically 40 radiation pulses and the final shape by the pulses that follow. The initially linear dependence of the magnitude of the first energy peak on the incident radiation intensity can be explained by complete shielding of the surface by the plasma layer within the given range of radiation intensity. All this points to a positive inverse relation between metal evaporation rate and optical thickness of the plasma layer, up to a certain limit above which the relation in some regions of the plasma layer becomes negative inverse. On the basis of this subsequent studies of evaporation dynamics in thin films and metal meshes as models of a massive target, a model for an eroding plasma layer has been refined into an optically nonuniform one with regions ranging from transparent to opaque. References: 8 Russian. [417-2415]

# NUMERICAL ANALYSIS OF EFFECT OF ERODING LASER PLASMA ON SURFACE EVAPORATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49, No 4, Apr 85 pp 783-790

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[Abstract] Evaporation of aluminum by laser radiation, with attendant formation of a plasma layer, is analyzed on the basis of the Knudsen model and applicable relations of radiative gas thermodynamics. As a most important parameter here is considered the Mach number,  $N_M = 0$  corresponding to ideal phase equilibrium  $N_M = 1$  corresponding to ideal evaporation. The more difficult problem with  $0 < N_M < 1$  among the variables is treated in the classical Stefan approximation. The corresponding system of six differential equations is solved for boundary conditions at an aluminum plate with perfect thermal insulation on the back side. The numerical solution for a 100  $\mu\text{m}$  thick aluminum plate and laser radiation of intensity  $G = 5 \cdot 10^8 e^{-2(t-t_1)^2/t_1^2}$

( $t_1 = 250$  ns) at the 1.06  $\mu\text{m}$  wavelength reveals that aluminum in such a system is evaporated during two relatively short time periods, first during  $16 \leq t \leq 80$  ns by laser radiation and then during  $275 \leq t \leq 325$  ns by intrinsic plasma radiation. Absorption of laser radiation by the plasma layer and plasma dispersal play an increasingly dominant role during the first period, plasma dispersal resulting in condensation equivalent to  $N_M < 0$ . This was taken into account by appropriate modification of the boundary conditions in the mathematical model. Cold vapor entering the gaseous region during the second period eventually terminates the evaporation process, despite the high surface temperature, and the model was appropriately modified to an isothermal one. Figures 4; references 31: 27 Russian, 4 Western (1 in Russian translation).

[417-2415]



SUBSURFACE PLASMA IN BEAM OF CONTINUOUS CO<sub>2</sub>-LASER

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49, No 4, Apr 85 pp 811-828

DANYTSIKOV, Ye. V., DYMSHAKOV, V. A., LEBEDEV, F. V., PIS'MENNYI, V. D. and RYAZANOV, A. V., Institute of Atomic Energy imeni I. V. Kuratov

[Abstract] A series of experiments was performed at the Institute of Atomic Energy, the purpose being to establish the conditions for formation of subsurface plasma in substances by laser radiation and to study its characteristics. A quasi-continuous CO<sub>2</sub>-laser emitting square pulses of 0.1-1.0 ms duration and 1-10 kW power as well as a continuous CO<sub>2</sub>-laser, the latter a laboratory version of the TL-10 industrial CO<sub>2</sub>-laser, served as radiation sources. Radiation was focused on spots 0.1-0.5 mm in diameter and maintained at levels ensuring constant power density during the interaction time, while the temperature of the target surface was measured continuously. Metals (Al, Ti, Ni, Cu, Zn, Nb, Mo, In, Ta, W, Pb, stainless steel, brass) as well as graphite and dielectrics (Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, micarta, acrylic glass) were included in the study, with laser action taking place in air N<sub>2</sub> + O<sub>2</sub> mixtures, Ar or He atmosphere under pressures of 0.01-1 atm. The study has yielded data on radiation intensity thresholds for evaporation and plasma formation: first as erosional plasma jets and then as optical discharge, after breakdown in vapor-gas mixture, in gas above the boiling point, or in vapor jets above the radiation intensity which yields complete evaporation, depending on the thermophysical properties of a substance such as melting point and absorptivity as well as on the oxidizing or inert ambient medium. On the basis of these thresholds, combined with data on the energy balance and the temperature profile in plasma layers, a universal state diagram has been constructed for subsurface plasma with nonquantified surface temperature and radiation intensity coordinates. Specialization of this diagram for specific substances and ambient media, with appropriately quantified coordinates, can be useful for designing and optimizing laser treatment of materials. It is noteworthy that a continuous CO<sub>2</sub>-laser, unlike a pulsed one, can produce steady optical discharge which lowers the efficiency of laser action, but a "hysteresis" factor in the ionization of the ambient gas allows treatment of materials at higher radiation intensities without triggering of optical discharge. Figures 11; tables 1; references 46: 38 Russian, 8 Western. [417-2415]

/9835

## LASERS

### METHOD FOR PHYSICAL MODELING OF PULSED GAS DISCHARGE LASERS

Moscow METOD FIZICHESKOGO MODELIROVANIYA IMPULSNYKH GAZORAZRYADNYKH LAZEROV in Russian 1983 pp 1-32

KRAVCHENKO, V. F., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] A method is developed for physical modeling of pulsed gas discharge laser systems that is based on the similarity of the processes responsible for lasing in pulsed gas discharge lasers. The similarity relationships for the plasma of an unsteady discharge, and for the radiation of a pulsed gas discharge laser, are presented. The criteria and similarity equation for the emitted energy density of pulsed gas discharge lasers are analyzed. The relationships derived for the similarity of optimal modes of gas discharge lasers and the radiation pulse energy density are compared with the experimental findings on self-heating lasers. The proposed physical modeling method is accurate enough for use in analyzing and designing other gas discharge lasers in which the mechanism by which inversion is created is similar to that of a Cu-Ne laser. The findings make it possible to develop an engineering method for calculating the maximum pulse energy from the initial optimal parameters of the active element and excitation source.

References 29: 23 Russian, 6 Western.

[438-6900]

### THEORETICAL INVESTIGATION OF CHARACTERISTICS OF ACTIVE MEDIUM AT 18.4 $\mu\text{m}$ IN PULSE GAS DISCHARGE CO<sub>2</sub> LASER ON 03<sup>1</sup>0-10<sup>0</sup>0 TRANSITION

Moscow TEORETICHESKOYE ISSLEDOVANIYE KHARAKTERISTIK AKTIVNOY SREDY NA DLINE VOLNY 18.8  $\mu\text{m}$  V IMPULSNOM GAZORAZRYADNOM CO<sub>2</sub>-LAZERE NA PEREKHODE 03<sup>1</sup>0-10<sup>0</sup>0 in Russian 1983 pp 2-28

ISLAMOV, R. Sh., KONEV, Yu. B., LIPATOV, N. I. and PASHININ, P. P., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] A method is presented for designing a gas-discharge laser employing long-wave transitions of CO<sub>2</sub> molecules that takes into account the processes in the system of lower levels. A quasiequilibrium model of the rotation kinetics of CO<sub>2</sub> is developed. The temporal evolution of the

distribution function of  $\text{CO}_2$  molecules with respect to vibration levels of multiplets of the symmetrical and deformation modes is analyzed. The calculations of the amplification index and lasing characteristics at  $18.4 \mu\text{m}$  indicate that substantial unit energy contribution, deep cooling, and careful purification of the mixture are required. Figures 8; references 11: 8 Russian, 3 Western.  
[438-6900]

#### THEORETICAL INVESTIGATION OF COOLED ELECTROIONIZATION CW $\text{CO}_2$ LASER

Moscow TEORETICHESKOYE ISSLEDOVANIYE OKHLAZHDAYEMOGO NEPRERYVNOGO ELEKTROIONIZATSIONNOGO  $\text{CO}_2$ -LAZERA in Russian 1982 pp 1-19

ZAIKIN, A. P., IGOSHIN, V. I. and KUPRIYANOV, N. L., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] A kinetic gas dynamic model of a CW electroionization  $\text{CO}_2$  laser is developed, and the lasing characteristics are optimized for limited mirror beam strength. A system of equations is derived to describe the behavior of the laser. Calculations are presented for a  $\text{CO}_2:\text{N}_2:\text{He}=1:5:4$  mixture. The optimum working pressure, corresponding to the maximum energy output for a cooled mixture is found to be approximately 0.1 atm for one version, and 0.15 atm for the second version. The same figure for an uncooled mixture is approximately 0.08 atm. Cryogenic cooling of the mixture almost triples the energy yield. Efficiencies of 11 and 12% are achieved. If the fixed beam strength of the mirrors is  $2 \text{ kW/cm}^2$ , the working pressures can be no more than doubled, therefore, no significant increase in electron beam utilization efficiency can be achieved under the conditions investigated. Figures 6; references 11: 7 Russian, 4 Western.  
[438-6900]

#### CALCULATION OF RADIATED POWER OF CHEMICAL OXYGEN LASER FOR CAVITIES WITH HOMOGENEOUS FIELD

Moscow RASCHET MOSHCHNOSTI IZLUCHENIYA KHIMICHESKOGO KISLORODNO-ODNOGO LAZERA DLYA REZONATOROV S ODNORODNYM POLEM in Russian 1983 pp 1-35

AZYAZOV, V. N., ZAGIDULLIN, M. V., IGOSHIN, V. I. and KUPRIYANOV, N. L., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] An analytical model is proposed for a CW chemical oxygen laser that discloses the relationship between the energy characteristics and the parameters of the active medium and cavity. The most important of these are the relationships between the specific energy characteristics and the concentration of extinguishing impurities ( $\text{H}_2\text{O}$ ,  $\text{H}_2\text{O}_2$ ,  $\text{Cl}_2$ ), and the intra-cavity intensity. The latter relationship makes it possible to identify the influence of restricting the intra-cavity intensity of the mirrors beam strength on the specific energy characteristics of the laser. Limiting the

intra-cavity intensity by the beam strength of the mirrors is found not to cause a significant drop in the energy characteristics. There is also no drop in the energy characteristics as the static pressure in the cavity increases, making it possible to scale the system by pressure. As the concentration of active particles increases, the gain of the active medium grows, which makes it possible to use unstable cavities. The numerical model can also be used to investigate the lasing energy yield as a function of the static pressure in the cavity, the mirror dimensions, the mixing lengths, etc. Figures 7; references 29: 12 Russian, 17 Western.  
[438-6900]

#### SIMULATION OF PARTICLE TRACKS BY LASER BEAM

Moscow IMITATSIYA TREKOV CHASTITS LAZERNYM LUCHOM in Russian 1983 pp 2-33

GUSHCHIN, Ye. M., LEBEDEV, A. N., SOMOV, S. V. and ZEMTSOV, S. S., Moscow Engineering-Physics Institute, Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] A method is described for simulating charged particle tracks by near-ultraviolet laser radiation. Two-photon ionization of the molecules of a series of complex organic compounds is investigated; it is shown that introducing their saturated vapors into the working cavity of the detector makes it possible to reduce the power of the laser radiation by several orders of magnitude, and to use the commercially produced LGI-21 N<sub>2</sub> laser to simulate the tracks of particles with practically any ionizing capability. Ionization through the S<sub>1</sub>, the S<sub>0</sub><sup>\*</sup> and S<sub>1</sub><sup>\*</sup>, and T<sub>1</sub> states are analyzed. The approach employed makes it possible to use a single laser to form several dozen laser tracks that simulate the particle tracks. The calculated two-quantum ionization cross-sections lie in the 10<sup>-44</sup>-10<sup>-50</sup> cm<sup>4</sup>.sec range. Different reaction channels and reaction kinetics are examined. Figures 4; references 32: 16 Russian, 16 Western.  
[438-6900]

#### INVESTIGATION OF CO<sub>2</sub> WAVEGUIDE LASER ACTIVE MEDIUM

Moscow ISSLEDOVANIYE AKTIVNOY SREDY VOLNOVODNOGO CO<sub>2</sub>-LAZERA in Russian 1983 pp 1-22

VERESHCHAGIN, K. A., VOLKOV, A. Yu., SVIRIDOV, A. G. and TSKHAY, S. N., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The indexes of amplification of the active medium of a waveguide CO<sub>2</sub> laser are measured for different vibration-rotation lines of the IR-transitions 00<sup>0</sup>1-02<sup>0</sup>0 and 00<sup>0</sup>1-10<sup>0</sup>0 of CO<sub>2</sub> molecules. Data from alpha measurements are used to determine the gas temperature values and the populations of the vibration levels of laser transitions (N<sub>001</sub>, N<sub>100</sub>, N<sub>020</sub>). The



reliability of the quantities obtained are analyzed, and the influence of the methods used to average the experimental values of  $\alpha$  on the results are studied. The role of systematic errors occurring because of indefiniteness of the physical constants used to calculate the gas temperature and the population of the vibration levels is defined. It is found that the level populations obtained under the conditions typical of waveguide lasers (on the basis of the measured amplification indexes) may be quite ambiguous, in part, because of the finite accuracy of the index of amplification and the values of the matrix elements of the vibration transitions, the cross-sections of the expanding collisions, etc. Tables 6; figures 2; references 15: 7 Russian, 8 Western.  
[438-6900]

#### ENERGETIC PROCESSES IN SOLID-STATE LASERS: ENERGY STORAGE MODE (Comparative analysis)

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P. N. LEBEDEVA  
in Russian Preprint No 104, 1984 KVANTOVAYA ELEKTRONIKA

GRADOV, V. M., KONSTANTINOV, B. A., MAK, A. A., NOVIKOV, V. Ye.,  
ROGALSKIY, Yu. I., SKLIZKOV, G. V., TERYENTYEV, Yu. I., FEDOTOV, S. I. and  
SHCHERBAKOV, A. A.

[Abstract] Storage of excitation energy in low-power solid-state lasers in the energy storage and monopulse emission mode is analyzed on the basis of the result of numerical simulation (simulation of transient processes taking into account a strong shielding of the excitation energy by the discharge). The efficiency in this mode is compared with that in the free emission mode for two types of lasers: type-I with a small discharge channel, which is also gauged here against one with a large discharge channel, and type-II with coaxial phototubes. Pumping with a square current pulse and with an aperiodic current pulse is considered. In the comparative performance evaluation, factors differently influencing the efficiency of both laser types are taken into account. These factors are activator concentration, mirror surface (diffuse or specular reflection), refractive index of the immersion medium, and width of the discharge gap. The dependence of the radial distribution of pumping power over the active medium in each type of laser on these factors as well as on the type of lateral surface (Fresnelian, diffusive-Fresnelian, diffusive) and the plasma temperature is also analyzed and comparatively evaluated. The results indicate that, unlike in the free emission mode, in the monopulse emission mode an appreciable weakening of superluminescence effects by a high pumping density can make the type-II laser more efficient than the type-I laser with large discharge channel. Figures 10; references: 10 Russian.  
[443-2415]



## ENERGETIC PROCESSES IN SOLID-STATE LASERS (NUMERICAL SIMULATION): ENERGY STORAGE MODE

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P. N. LEBEDEVA  
in Russian Preprint No 140, 1984 KVANTOVAYA ELEKTRONIKA

GRADOV, V. M., KROMSKIY, G. I., MAK, A. A., SKLIZKOV, G. V., SMOTRYAYEV, S. A.,  
TERENTYEV, Yu. I., FEDOTOV, S. I. and SHCHERBAKOV, A. A.

[Abstract] The dynamic characteristics of excitation energy storage in solid-state lasers operating in the monopulse emission mode are comprehensively described by a theoretical model suitable, with the aid of selective experimental data, for numerical analysis by the Monte Carlo method. A four-level active medium is considered. The corresponding equations of population balance and laser transition kinetics, including excitation of its metastable third (upper) level, are formulated so as to be applicable to the particles' storage mode as well as to intermittent emission in the quasi-steady approximation. These equations are supplemented with equations of the radiation field, including induced radiation as well as luminescence and phototube radiation. Efficiency of energy storage for intermittent emission, or amplification, serves as criterion for evaluating the performance of type-I lasers (phototube inside cavity of active medium) which approach the "Ideal luminous boiler" on the basis of this all-inclusive model with superluminescence and noise effects also taken into account. Losses in the active medium at the lasing transition, in the immersion medium, and by reflection at the walls are accounted for, as is also the dependence of the current cutoff timing on the amount of stored energy, the time of cutoff corresponding to saturation of energy storage and optimizable to match the operating conditions. Figures 15; references 73: 57 Russian, 16 Western.  
[443-2415]

## SELF-CONSISTENT ANALYSIS OF KINETICS OF ELEMENTARY PROCESSES IN ELECTROIONIZATION-TYPE CO-LASER

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P. N. LEBEDEVA  
in Russian Preprint No 183, 1984

BASOV, N. G., DOLININA, V. I., KOVSH, I. B., PYATAKHIN, M. V. and URIN, B. M.

[Abstract] A self-consistent analysis of the kinetics of elementary processes in an electroionization-type CO-laser is performed, for design purposes, in order to resolve existing quantitative differences between theoretical predictions of laser performance and available experimental data. This is done by simultaneously solving the Boltzmann equation of kinetics for the electron energy distribution function and the equation of vibrational kinetics. Step-by-step excitation of molecules by electrons and collisions of the second kind between electrons and vibrationally excited molecules are taken into consideration. The dynamics of energy balance and the electron drift velocity as well

as other electron transport coefficients, namely ratio of transverse diffusion coefficient to mobility, and weak-signal amplification at vibrational-rotational transitions are calculated for pure CO so as to fully account for the change in "electron-kinetics - vibrational kinetics" interaction energy stored in vibrational degrees of freedom. The system of equations of this model covers vibrational kinetics in the single-quantum approximation, change of CO gas temperature, and the energy distribution of electrons in a uniform electric field in the steady-state one-dimensional case, assuming a constant E/N ratio of electric field intensity to concentration of gas particles. This system of equations has been solved by the numerical methods of successive executions and elimination, assuming instantaneous turn-on and turn-off of the discharge pulse. The results reveal how the electron energy distribution during discharge depends on the population of vibrational levels. The electron energy distribution in turn influences the discharge characteristics and the distribution of molecules over vibrational levels is influenced by the electron kinetics. The mean electron energy and the ratio of transverse diffusion coefficient to mobility increase but the electron drift velocity and the efficiency of vibrations excitation decrease as the population of vibrational levels increases and a larger fraction of pumping energy is converted into heat. In addition to the vibrational kinetics and the weak-signal gain characteristics, the results of this analysis also yield the temperature dependence of the instability timing. Figures 15; references 29: 17 Russian, 12 Western.  
[443-2415]

UDC: 621.375.8

#### OPTIMIZATION OF PARAMETERS OF A COPPER LASER WITH SHORT EXCITATION PULSES

Kiev KVANTOVAYA ELEKTRONIKA in Russian No 28, 1985  
(manuscript received 27 Dec 83) pp 99-101

VORONYUK, L. V., GRECHKO, L. G., PINKEVICH, I. P., SELISHCHEV, P. A. and SIDENKO, T. S., Kiev State University imeni T. G. Shevchenko

[Abstract] In order to increase the energy output of a laser, the electron temperature of the plasma should be increased, which is not always possible. This work suggests that addition of easily ionized cesium atoms be used as a controlling element for the energy parameters of a copper vapor laser operating at relatively low electron temperature, not over about 5 eV. The additional free electrons which appear in this case lead to somewhat earlier beginning of generation and decrease the length of the pulse generated for constant electron temperature. By changing the concentration of cesium atoms it is thus possible to regulate the beginning and length of the generated pulse, facilitating generation with lower losses on spontaneous radiation decay at a better electron temperature. Figure 1; references: 4 Russian.  
[048-6508]

## THEORETICAL STUDY OF PHOTOCHEMICAL XeO LASER EXCITED IN PHOTOCLEARIFICATION WAVE

Kiev KVANTOVAYA ELEKTRONIKA in Russian, No 28, 1985  
(manuscript received 22 Nov 83) pp 3-14

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[Abstract] A theoretical study is presented of a photochemical eximer XeO laser. The space-time characteristics of the laser in the one-dimensional photoclearification wave mode are determined. The population inversion criterion and heat liberation during photolysis are calculated. Operation of the photochemical XeO laser during pulse generation is analyzed. It is shown that intense external radiation results in propagation of a steady photoclearification wave through the  $N_2O:Xe$  medium, followed by an inversion wave. The inversion population of XeO molecules is studied, showing that heat liberation and emptying of the lower laser state has a significant influence on the inversion criterion. Natural oscillation of an inhomogeneous resonator with infinite flat mirrors is found. The internal quantum yield of utilization of excited atoms is found to be close to one. Figures 3; references 15: 14 Russian, 1 Western.  
[048-6508]

UDC 621.378

## DISTRIBUTION OF ENERGY EMITTED BY PARTICLES IN FREE ELECTRON LASER OVER BEAM CROSS-SECTION

Moscow KRATKIYE SOOBSHCHENIYA PO FIZIKE: SBORNIK in Russian No 1,  
Jan 85 (manuscript received 8 Aug 84) pp 11-14

SEROV, A. V.

[Abstract] Calculations are made of the energy emitted and thus lost by electrons in an electron laser. The distribution of this energy over the beam cross-section is then established and its dependence on the intensity of the electromagnetic wave field in which the electrons move is determined. Analysis of the problem is based on the equations of electron ballistics and calculations are based on numerical solution of these equations. The energy emitted by electrons is determined by their interaction with the electromagnetic wave beam, while the dependence of this energy on the field intensity is largely affected by the field nonuniformity and by the finiteness of the electron beam dimensions. When the cross-section of the electron beam is much smaller than that of the electromagnetic wave beam, then the laser should preferably operate with a field-dependent variable cross-section of the electron beam during injection. Figures 2; references: 2 Russian.  
[567-2415]

## KINETICS OF INTRACAVITY ABSORPTION IN RESONATORS OF PULSED DYE LASERS

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 29, No 8, Aug 85

(manuscript received 5 Oct 84) pp 700-703

BURAKOV, V. S., corresponding member, BSSR Academy of Sciences, MALASHONOK, V. A., NECHAYEV, S. V., PUKO, R. A., RAYKOV, S. N. and SHEDENKOV, S. I., Institute of Physics, BSSR Academy of Sciences

[Abstract] An experimental study of pulsed dye lasers was made pertaining to the kinetics of intracavity absorption in their Fabry-Perot resonator, such lasers being pumped either optically or with second-harmonic radiation from a ruby laser. Selective absorption was ensured by use of water and ethanol solutions of  $\text{Eu}(\text{NO}_3)_3$  with a characteristically narrow absorption band (0.4 nm corresponding to the  ${}^7\text{F}_0 \rightarrow {}^5\text{D}_0$  transition within the emission range of a rhodamine-6Zh laser), their optical density being varied either by varying their concentration or by scanning the contour of their absorption band with the concentration fixed. The laser emission intensity with and without selective absorption,  $I$  and  $I_0$  respectively, was measured as a function of time at various levels of optical loss density ranging from  $5 \cdot 10^{-4}$  to  $22.3 \cdot 10^{-4}$ . The analytic signal  $I$  and the reference signal  $I_0$  were each passed through a diffractive monochromator and recorded by a photoreceiver with adequate time resolution. The data have been processed and evaluated in terms of the ratio  $\Delta I/I_0$  ( $\Delta I = I - I_0$ ), and also compared with theoretical estimates for a pulsed dye laser and with available data on continuous-wave dye lasers pumped both ways. The results indicate that stabilization of emission in the case of a pulsed dye laser with a Fabry-Perot resonator is effected by three concurrent mechanisms, namely spontaneous emission and spatial depletion of inverse population occurring simultaneously with competition between modes. The first two mechanisms produce a dip of  $\Delta I/I_0$  throughout the emission period, while the intensity of mode competition changes in time from maximum initially to negligible in the steady state. This third mechanism, accordingly, governs the kinetics of intracavity absorption in the resonator of multimode dye lasers emitting microsecond pulses of duration longer than the stabilization time. Figures 2; references 8: 2 Russian, 6 Western.

[572-2415]



## SPECTRAL AND TEMPORAL CHARACTERISTICS OF MONOLITHIC HYBRID BRAGG-MIRROR HETEROLASER RADIATION

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 11, No 10, 26 May 85 (manuscript received 19 Mar 85) pp 606-611

GUREVICH, S. A., NESTEROV, S. I., PORTNOY, Ye. L., SKOPINA, V. I. and TIMOFEYEV, F. N., Physical-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] The spectral and temporal characteristics of the radiation produced by a monolithic hybrid Bragg heterolaser are investigated. A monolithic hybrid strip laser is studied that operates in the single-frequency mode significantly above the threshold current employing long (60 nsec) and short (approximately 450 psec) pumping pulses. The amplifying region in the laser is based on an AlGaAs-GaAs heterostructure, with a five-layer optical waveguide interfaced end-to-end on a common substrate with a corrugated waveguide made of SiO<sub>2</sub>, Ta<sub>2</sub>O<sub>5</sub>, and As<sub>2</sub>S<sub>3</sub> layers, which forms a distributed Bragg mirror. The power-current characteristic of the device and its lasing spectra are investigated, showing a linear relationship between the emitted pulse power and the pumping current. The fundamental mode of the semiconductor strip waveguide is found to be excited in the amplifying region. The Bragg mirror is found to provide transverse stabilization of the optical field, apparently because of the stability of the near field and the linearity of the power-current characteristic. Figures 4; references 5: 4 Russian, 1 Western.

[507-6900]

## STABILITY OF HOMOGENEOUS PUMPING STAGE OF ELECTRIC DISCHARGE EXCIMER LASERS

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 11, No 10, 26 May 85 (manuscript received 11 Feb 85) pp 627-631

BAGINSKIY, V. M., BASOV, N. G., POLOVINSKIY, P. N., DANILUCHEV, V. A., MILANICH, A. I., SOROKA, A. M. and SHCHEDRIN, A. I.

[Abstract] The influence of photoionization by intrinsic radiation on the discharge parameters and stability of a XeCl\*-discharge laser are investigated. The fundamental processes occurring in the excimer laser plasma are studied. Formulas are derived for the rate of step ionization by electrons:

$$k_1 n_e = \frac{\delta_1 I_{st}}{h\nu} \text{ and } k_1 n_e [\text{Xe}^*(p)] = \frac{\delta d I_{st}}{h\nu} [\text{Cl}^-]. \text{ The stability of the homogeneous}$$

stage of discharge combustion is investigated in the active area of a discharge laser. The duration of stable combustion is found to be governed by the laser flux in the cavity. This time exceeds the HCl "production" time for values of approximately 10 MW/cm<sup>2</sup>, so that all of the fundamental energy is extracted. Figures 2; references: 6 Russian.

[507-6900]



INFLUENCE ON RADIATION DIVERGENCE OF RAMAN SCATTERING IN GAS LASER ACTIVE MEDIUM WITH ELECTRICAL FIELD PUMPING

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 11, No 10, 26 May 85 (manuscript received 11 Feb 85) pp 591-594

BASOV, N. G., DANILYCHEV, V. A., RUDOV, I. G. and SOROKA, A. M., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The influence of Raman scattering on the radiation divergence of CO<sub>2</sub> lasers employing electrical-field pumping is investigated. Pulses exceeding 10  $\mu$ sec and angles of approximately  $5 \cdot 10^{-4}$  rad, which are sufficient for most practical purposes, are investigated. It is shown possible to reduce the divergence by reducing the angular aperture of the cavity mirrors. This can be done by employing a separate cavity with the active medium filling only part of its volume. Increasing the cavity length also increases the number of longitudinal modes, which improves the directivity of the radiation. The proposed approaches make it possible to reduce the influence of nonlinear effects and thus to achieve the diffraction limit in gas lasers. References: 7 Russian.  
[507-6900]

0.677  $\mu$ m CW INJECTION SEPARATE-CONFINEMENT InGaAsP/GaAsP DUAL HETEROSTRUCTURE LASER PRODUCED BY LIQUID EPITAXY

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 19, No 6, Jun 85 (manuscript received 12 Feb 84) pp 1115-1118

ALFEROV, Zh. I., ARSENT'EV, I. N., VAVILOVA, L. S., GARBUZOVA, D. Z., KRASOVSKIY, V. V., TINKUNOV, A. V. and CHALYJ, V. P., Physical-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] Low-threshold separate-confinement InGaAsP/GaAsP dual heterostructure lasers operating at  $\lambda = 0.677 \mu$ m, and their use to produce continuous lasing, are described. The original structures are grown by liquid epitaxy from indium melts on GaAs-GaAs<sub>0.6</sub>P<sub>0.4</sub> gas-transport structures. The low thresholds (approximately 1 kA/cm<sup>2</sup>) and small series resistances obtained in the specimens made it possible to achieve continuous lasing at shorter wavelengths ( $< 0.68 \mu$ m) than in other existing injection radiators. It is suggested that the threshold current density can be made even smaller by reducing the thickness of the active region. Figures 2; references 11: 7 Russian, 4 Western.  
[525-6900]

## INJECTION LASER AMPLITUDE-MODULATED RADIATION RECEIVER

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 11, No 8,  
26 Apr 85 (manuscript received 18 Nov 84) pp 485-487

DEMENTIYENKO, V. V., GODIK, E. E., GULYAYEV, Yu. V. and L'VOVA, M. V.

[Abstract] A study was made of the response of a current circuit containing a semiconductor laser to an amplitude-modulated signal. Amplitude rather than phase modulation of the radiation was used. The study of the variation of the amplitude-modulated signal as a function of pumping current with a constant level of returned power in the resonator revealed that as the current was increased the current response increased up to  $I_{th}$ , while at over  $I_{th}$  alternating peaks and valleys were observed. The signal amplitude reached 100 microamperes. The watt-ampere characteristic of the laser was normal with a break at the threshold and with no specifics in the area of currents corresponding to nonmonotonic change of the response. Figure 1; references 4: 3 Russian, 1 Western.  
[508-6508]

UDC: 537.533

## FORMATION OF ELECTRON BEAMS IN RECHARGING LAYER UPON DISCHARGE IN MEDIUM PRESSURE GASES

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 55, No 6, Jun 85  
(manuscript received 22 Sep 83; in final form 11 Sep 84) pp 1168-1170

BOKHAN, P. A. and SOROKIN, A. R., Institute of Heat Physics, USSR Academy of Sciences, Siberian Department, Novosibirsk

[Abstract] A method is described for production of electron beams in a discharge between a screen cathode and positive space charge external with respect to the small discharge gap. Experiments were performed with a discharge between two screen electrodes of 1 cm<sup>2</sup>, geometric transparency factor 0.75, placed in a glass tube 2 cm in diameter. Electron beam currents were measured either by a moving collector or by an optical method. It was found that upon discharge in a small gap the formation of the space charge caused by ions injected beyond the screen cathode leads to generation of an intensive electron beam with near 100% effectiveness. The first experiments on excitation of lasers with such electron beams have shown that the effectiveness of the lasers is increased by a factor of 2 or more in comparison to ordinary bypass electron beams. Figures 2; references: 8 Russian.  
[497-6508]

EXPERIMENTAL STUDY OF RADIATION SPECTRA OF HYBRID CO<sub>2</sub> LASER BASED ON ROTATIONAL LINES

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 55, No 6, Jun 85  
(manuscript received 1 Aug 84) pp 1099-1104

BULANIN, V. V., NEZHENTSEV, B. Yu. and USHAKOV, S. N., Leningrad  
Polytechnical Institute imeni M. I. Kalinin

[Abstract] An experimental study is presented of the structure of the spectra of a hybrid pulsed CO<sub>2</sub> laser under various operating conditions. Factors influencing the evolution of the spectrum are noted. Conditions under which single-mode lasing is achieved are determined. For the first time, the radiation spectra of this type of laser are studied on the basis of rotational lines under various operating conditions over a broad range of intensity of individual lines. It is found that the most characteristic process under hybrid operating conditions with fixed initial radiation line other than P<sub>20</sub> is appearance of the line in the spectrum toward the end of the radiation pulse with suppression of the initial lasing line. This process is not very sensitive to depth of modulation of gain and can serve as an additional cause of the development of intermode beating in the hybrid laser pulse without selection of rotational lines by passive resonator elements. Figures 3; references 13: 3 Russian, 10 Western.  
[497-6508]

EXPERIMENTAL FIBER-OPTIC CABLE FOR TRANSMISSION OF HIGH POWERED CO- AND CO<sub>2</sub>-LASER RADIATION

Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 11, No 12,  
26 Jun 85 (manuscript received 7 Feb 85) pp 757-760

ALEJNIKOV, V. S., ARTYUSHENKO, V. G., BOYTSEKHOVSKIY, V. V., DIANOV, Ye. M.,  
ZUBOV, I. V., MASYCHEV, V. I., SABENKOVA, T. N. and SYSOYEV, V. K.,  
Institute of General Physics, USSR Academy of Sciences, Moscow

[Abstract] Results are presented from work on the creation and study of an experimental fiber-optic cable based on polycrystalline KRS-5 lightguides designed for transmission of powerful CO and CO<sub>2</sub> laser beams. A photograph of the model tested is presented. The polycrystalline lightguide was manufactured by extrusion, lightguide diameter 1 mm, length 1.2 mm, mean grain size 3 micrometers. Optical losses in the 5-6 micrometer band did not exceed 1.5 dB/m, including not over 1 dB/m absorption, and at 10.6 micrometers wavelength - 0.5 dB/m. The minimum bending radius of the waveguide was found to be 5 cm. A metal collar containing a gallium arsenide lens was used as a hand pointing tool. Radiation divergence from the end of the lightguide was 30-60°, and was focused by the lens to a spot slightly larger in diameter than the lightguide. Power density in the focal plane was as high as

0.5-0.7 kW/cm<sup>2</sup> for the CO laser, 1.2-1.5 kW/cm<sup>2</sup> for the CO<sub>2</sub> laser.  
Figures 2; references 7: 4 Russian, 3 Western.  
[529-6508]

#### INFLUENCE ON INJECTION LASER SPECTRUM OF REFRACTION COEFFICIENT AS FUNCTION OF CARRIER CONCENTRATION

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 19, No 3, Mar 85  
(manuscript received 20 Jul 84) pp 427-433

SURIS, R. A. and TAGER, A. A., Institute of Electrical Engineering and Electronics, USSR Academy of Sciences

[Abstract] The influence of the connection between the carrier concentration in a semiconductor laser and fluctuations in the coefficient of refraction on the region of multiple-mode lasing caused by spontaneous emission is investigated. The radiation spectrum is found using the approximation of small fluctuations, where the contribution of the center line to the total power exceeds the contribution of adjacent modes. The conditions for single-mode lasing are then derived and investigated in terms of their connection with the parameters of the semiconductor laser. It is found that beating of the carrier concentration at frequencies between modes caused by interference of the laser line by noise in adjacent longitudinal modes causes increased radiation power in those modes. References 13: 7 Russian, 6 Western.  
[367-6900]

#### THRESHOLD CURRENT CALCULATION FOR InGaAsP/InP AND InGaAsP/GaAs SEPARATELY CONFINED DUAL HETEROSTRUCTURE LASERS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 19, No 3, Mar 85 (manuscript received 19 Sep 84) pp 449-455

GARVUZOV, D. Z., YEVTIKHIYEV, V. P., KARPOV, S. Yu., SOKOLOVA, Z. N. and KHALFIN, V. B., Physical-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] The threshold current density is investigated in separately confined dual heterostructure injection lasers, in which two additional waveguide lasers with a total thickness of D occur in addition to the narrow-zone active region with thickness d. The relationship between the optical confinement factor, as well as different types of losses, and the thickness of the active region are included in the calculation. The output losses are shown to have a strong influence on the relationship between the thresholds and d: when there are no output losses, the threshold current densities drop off almost linearly as the active region becomes thinner;



when the output losses are high, the thresholds cease decreasing as the thresholds become smaller. The threshold current densities obtained are the lower limit, inasmuch as a number of factors that increase the thresholds in real structures are disregarded. Comparison of the calculated and experimental thresholds demonstrates the feasibility of using the analytical method for determining other laser characteristics, such as differential efficiency and the temperature behavior of the threshold currents.

References 21: 13 Russian, 8 Western.

[367-6900]

UDC: 621.373.826.038.825.2

#### LiF DYE CENTER LASER WITH OUTPUT ENERGY OF 100 J

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85

(manuscript received 7 Feb 85) pp 1125-1126

BASIYEV, T. T., YERSHOV, B. V., KRAVTSOV, S. B., MIROV, S. B., SPIRIDONOV, V. A. and FEDOROV, V. B., Institute of General Physics, USSR Academy of Sciences, Moscow

[Abstract] A report is presented on the creation of an effective laser based on a large  $\text{LiF:F}^{2-}_2$  crystal with a volume of  $640 \text{ cm}^3$ , radiating aperture  $80 \text{ cm}^2$ . Transverse pumping of the crystal by the radiation of a pulsed neodymium laser is used. The lithium fluoride crystal measures  $4 \times 8 \times 20 \text{ cm}$ . The resonator was formed with flat dielectric mirrors, reflection coefficient at  $1.1\text{--}1.5$  micrometers 99 and 50%. The resonator length was not over 30 cm. The crystal was placed in the resonator so that the  $4 \times 20 \text{ cm}$  face was parallel to the mirrors and acted as the radiating aperture, the  $8 \times 20 \text{ cm}$  perpendicular face being used for pumping. Figure 1; references: 4 Russian.

[503-6508]

UDC: 621.373.826.038.823

#### CONTINUOUS CHEMICAL TRANSFER LASERS (REVIEW)

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85

(manuscript received 16 Oct 84) pp 1127-1173

STEPANOV, A. A., SHCHEGLOV, V. A. and YURYSHEV, N. N., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] The current status of the problem of continuous chemical transfer lasers is discussed, including their operating principle and basic peculiarities, results of experimental operation and theoretical studies, and the possibility of creating transfer lasers on the basis of multiatomic molecule cascade junctions. The prospects for development of this type of laser are discussed. The major trends in the development of chemical transfer lasers include study and creation of supersonic independent  $\text{DF-CO}_2$  lasers with high specific energy characteristics and the search for new



atomic systems, the use of directed modification of thermodynamic, energy and optical properties of laser media by pure gas dynamic methods, the search for effective systems for the creation of new classes of lasers of this type and expansion of their spectral range. New and effective systems are being sought using the mechanisms of EE or EV exchange for the creation of new electron junction lasers. Systems are desired with high optical homogeneity of the active medium and optical systems providing for good output radiation quality. Figures 23; references 209: 69 Russian, 140 Western.  
[503-6508]

UDC: 621.373.826.038.823

#### STUDY OF STRONTIUM VAPOR LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85  
(manuscript received 10 Jul 84) pp 1261-1269

PROKOP'YEV, V. Ye. and SOLOMONOV, V. I., Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk

[Abstract] An experimental study is presented of the behavior of spontaneous and induced laser radiation in strontium vapor mixed with helium. The dynamics of metastable  $4d^2D_{5/2}Sr^+$  level population decay and its relationship to the energy characteristics of laser radiation are studied. The results obtained and the behavior of power in the second pulse can be easily explained based on classic representation of relaxation processes occurring in a decaying gas discharge plasma. The minimum delay time for generation by self-limited transitions of the strontium atom and ion corresponds to the end of rapid breakdown of the metastable level population, i.e., the relaxation time of the gas discharge plasma electron temperature to the quasisteady level. Figures 5; references 12: 9 Russian, 3 Western.  
[503-6508]

# INCREASING STABILITY OF A CONTINUOUS DYE LASER WITH SYNCHRONOUS EXCITATION BY INTRODUCTION OF NONLINEAR ABSORBER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85  
(manuscript received 12 Oct 84) pp 1279-1281

GAFUROV, Kh. G., KRINDACH, D. P., NEKHAYENKO, V. A. and YAKOVLEV, A. G.,  
Moscow State University imeni M. V. Lomonosov

[Abstract] An experimental study is presented of the lasing of a continuous laser based on a mixture of Rh6G (amplifier) and malachite green (absorber) synchronously excited by the radiation of an Ar<sup>+</sup> laser with passive mode synchronization. Synchronous excitation of Rh6G was the dominant mechanism of mode synchronization, supplementing the effect of the saturated absorber. A decrease was observed in the length of pulses from about 1.5 ps with synchronous excitation of pure Rh6G to 0.7±0.2 ps with the combined method. The results show a significant increase in lasing mode stability. With combined mode synchronization, pulse length under steady conditions is determined by the dynamics of saturation of both absorption and amplification. The effect of the saturating absorber manifests the same regularities as with passive mode synchronization. With combined mode synchronization the possibility of using dyes with high saturation parameters significantly expands the range of selection of the saturating absorber. Figures 4; references 10; 6 Russian, 4 Western.  
[503-6508]

# LIMITING PARAMETERS OF ULTRASHORT PULSES IN LANTHANUM BERYLLATE LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85  
(manuscript received 28 Aug 84) pp 1304-1307

DEMCHUK, M. I., MIKHAYLOV, V. P., GILEV, A. K., SHKADAREVICH, A. P.,  
STAVROV, A. A. and KOVALEV, D. V., Scientific Research Institute of Applied  
Physics Problems imeni A. N. Sevchenko, Belorussian State University, Minsk

[Abstract] A study is presented of the maximum time and energy parameters of ultrashort pulses in a lanthanum beryllate laser in order to determine factors limiting these characteristics. Experiments were performed on a laser with a hemispherical resonator consisting of a spherical mirror with radius of curvature 3.33 m and reflection coefficient 99%. The mirror plus a 1 degree wedge form a cuvette about 200 micrometers thick in which a solution of non-saturating absorbent is in optical contact with the mirror. The neodymium content in the lanthanum beryllate crystal was 3%. A number of dyes with various nonlinear parameters were used to study passive mode synchronization.

Ultrashort pulse energy increases with increasing intensity of clarification of the passive trap. Maximum energy was achieved with a solution of dye 3321 in dichloroethane: 0.75 GW. Dyes 3321 and 3281 were optimal in terms of minimum duration and maximum energy of ultrashort pulses. Pulses of 5 ps and 4 ps were achieved for 3281 and 3321, respectively. References 9: 4 Russian, 5 Western.  
[503-6508]

UDC: 621.373.826.038.825.4

#### AMPLITUDE MODULATION OF RADIATION OF SINGLE-FREQUENCY INJECTION LASER WITH HARMONIC CURRENT SIGNAL

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85  
(manuscript received 29 May 84) pp 1314-1316

MALAKHOVA, V. I., SOLODKOV, A. F. and YAKUBOVICH, S. D., All-Union Scientific Research Institute of Optical-Physical Measurements, Moscow

[Abstract] A number of designs have recently been created of channel injection lasers with good waveguide resonators in which stable generation of a single dominant mode is achieved with significant excess over the threshold. Laboratory specimens studied in this work were GaAs homolasers with a waveguide width of 10 micrometers, length 200 micrometers, operating at cryogenic temperatures and having practically linear watt-ampere characteristics for single-frequency generation up to an output power of 100 mW. A modulating signal was applied through a radio frequency cable and a matching load of 50 Ohms for constant pumping current. Modulation depths are presented for several modulation frequencies. Nonlinear distortion was also determined. A decrease in modulation effectiveness with increasing frequency was observed, a result primarily of nonideal matching with the RF line and the capacitive component of current through the laser diode. Modulation depth was still approximately 100% at all frequencies with practically no nonlinear distortion. Figures 2; references 7: 4 Russian, 3 Western.  
[503-6508]

UDC: 621.378.31:528

#### METHOD OF MEASURING DISTANCES BY BEAT FREQUENCY LIGHT RANGE FINDER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85  
(manuscript received 11 Jun 84) pp 1318-1319

ASNIS, L. N., BLATOV, I. V., MOSKALENKO, A. V., POPOV, Yu. V. and REMIZOV, S. A.

[Abstract] Experiments were performed with a heterodyne system operating at 10.6 micrometers using a type LG-74 CO<sub>2</sub> laser with a piezocorrector

operating at 800 Hz. Measurements were performed over a path length of 2.5 km. Unambiguous range determination was possible up to the limits established by the piezocorrector. Measurement error is a few meters at maximum range.

Figures 2.

[503-6508]

UDC: 621.373.826.038.825

#### WIDTH OF AREA OF ACTIVE MODE SYNCHRONIZATION IN SOLID STATE LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85

(manuscript received 19 Sep 84) pp 1322-1324

LARIONTSEV, Ye. G., Scientific Research Institute of Nuclear Physics;  
Moscow State University imeni M. V. Lomonosov

[Abstract] A theoretical study is presented of the area of stability of active mode synchronization in a garnet laser with neodymium. A new mechanism is discussed limiting the width of the area of stability of active mode synchronization with periodic modulation of losses relative to two types of disturbances; small variations in ultrashort pulse parameters and excitation of additional ultrashort pulses due to spontaneous radiation noise. Excitation of additional ultrashort pulses limits the width of the zone of steady active mode synchronization. Figure 1; references 4: 3 Russian, 1 Western.

[503-6508]

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## MAGNETOHYDRODYNAMICS

### 25-MEGAWATT MHD POWER GENERATOR UNDER CONSTRUCTION

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian No 205 (4896), 6 Sep 85, p 2, cols 1-5

[Article by S. Borisova, correspondent of the USSR Ministry of Power and Electrification's press center (Kokhtla-Yarve, Estonian SSR)]

[Excerpt] At the Kokhtla-Yarve Power and Heating Plant in Estonia, construction workers are building a unique magnetohydrodynamic unit in collaboration with specialists of the State Scientific Research Institute of Power Engineering imeni Krzhizhanovskiy.

Several experimental MHD power units are already operating in our country. What distinguishes the one that is under construction in Kokhtla-Yarve from them?

"In the first place, all of the earlier units are test units with lower capacities," explained S. Golishevich, head of the group of power-engineering specialists. "Our unit's capacity of 25 megawatts offers the possibility of generating current on a commercial scale. In the second place, the existing units burn gas, while the one that is under construction will burn solid fuel."

The scientists and engineers who are taking part in its construction have encountered a number of complex scientific and technical problems. First of all, effective materials had to be developed for MHD channels in which thermal energy is converted into electric power. The walls of these channels and electrodes have to withstand the prolonged action of extraordinarily high temperatures. It was also not easy to achieve superconductivity in magnets and reliability of devices for converting the direct current obtained in the MHD generator into alternating current.

These problems are now behind them. Installation work is in full swing at the construction site.

"Rigid construction deadlines have been set," said V. Tupikin, head of the Kokhtla-Yarve plant's experimental section. "The unit is to be started up this year."

FTD/SNAP/9835  
CSO: 1862/041



UDC 621.313.12.538.4

DEPENDENCE OF INTEGRAL CHARACTERISTICS OF DIAGONAL MHD-GENERATOR ON SHAPE OF MHD-CHANNEL CROSS-SECTION

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 49, No 2, Aug 85  
(manuscript received 25 Jul 84) pp 291-298

BELOGLAZOV, A. A., BERKOVSKIY, B. M., CHERBOVA, V. I. and SHEVCHENKO, A. L.,  
Institute of High Temperatures, USSR Academy of Sciences, Moscow

[Abstract] Shaping the cross-section of an MHD channel for equalization of the Hall emf and minimization of parasitic currents in a nonhomogeneous plasma is analyzed on the basis of the one-dimensional electrodynamic model, and the effect of nonrectangularity on the performance of an MHD generator is evaluated for a machine with a diagonally connected load. Calculations are made for a metallized solid high-enthalpy fuel, using two auxiliary functions for description of both enthalpy and entropy profiles. Supersonic flow through the channel is described by a system of four quasi-one-dimensional MHD equations, including the equation of continuity and the equation of state as well as the energy equation along with the equation of motion. Buildup of a turbulent boundary layer in accordance with the "one-seventh power" law and radiative heat transfer in terms of the mean effective emissivity are taken into account. The geometrical design target function is stipulated implicitly, the object being to shape the channel cross-section so that the Mach number will nowhere decrease to unity and thus no "stalling" will occur. It is found possible to optimize the generator performance by shaping the channel cross-section for the flow of fuel combustion products. Assuming a uniform magnetic induction in large channel volumes yields adequately favorable results, a peaking magnetic induction in smaller channel volumes should yield even more favorable results. Figures 3; tables 3; references 8: 6 Russian, 2 Western (?) (both in Russian translation).  
[593-2415]

/9835

## MOLECULAR PHYSICS

### DYNAMICS OF VIBRATIONAL EXCITATION AND HEATING OF NITROGEN DURING AND AFTER MICROWAVE PULSE DISCHARGE

Moscow DINAMIKA KOLEBATELNOGO VOZBUZHDENIYA I NAGREVA AZOTA V PROTSESSE I POSLE IMPULSNOGO SVCh RAZRYADA in Russian 1983 pp 1-19

GRITSININ, S. I., KOSSYY, I. A., TARASOVA, N. M., Physics Institute imeni P. N. Lebedeva, USSR Academy of Sciences, and Silakov, V. P., Moscow Engineering-Physics Institute

[Abstract] An experimental setup is devised for studying the physical phenomena occurring in nonequilibrium gases during and after a microwave discharge in order to determine the dynamics of the population of the vibrational levels of the molecules, as well as the relaxation dynamics for strongly nonequilibrium conditions. The trace method is used to investigate the dynamics of the excitation and relaxation of the vibration state of nitrogen molecules in a volume occupied by a microwave discharge, and to determine the translational temperature of the gas after equilibrium is established in that discharge region. Oscillograms of the IR radiation exhibit three regions in the temporal behavior of the signal. A relatively slight increase in the signal immediately after pumping begins is followed by a plateau which, in turn, is followed by a near-exponential drop in the signal with a time constant of the order of several milliseconds. The duration of the first and second stages depends upon the experimental conditions and the place of observation, and ranges from 0 to 1-2 milliseconds. The analytical findings agree well with the experimental picture of the relaxation of nonequilibrium nitrogen during the post-discharge period. Quantitative discrepancies are noted that result from the failure to account for a number of factors in the idealized analytical model. Figures 6; references 18: 10 Russian, 8 Western.

[438-6900]

/9835

## NUCLEAR PHYSICS

### NUMERICAL MODELING OF FILAMENTATION AND SELF-FOCUSING OF LASER BEAMS IN CORONA OF SPHERICAL TARGETS

Moscow CHISLENNOYE MODELIROVANIYE FILAMENTATSII I SAMOFOKUSIROVKI LAZERNYKH  
PUCHKOV V KORONE SFERICHESKIKH MISHENEY in Russian 1983 pp 1-25

LEBO, I. G., LIMPOUKH, I. and ROZANOV, V. B., Physics Institute  
imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The effects of filamentation and self-focusing of light beams are investigated theoretically in the corona of spherical laser targets having parameters similar to contemporary experimental or future predicted experimental laser thermonuclear fusion. The basic similarity relationships obtained for target and radiation parameters that characterize filamentation and self-focusing effects of laser beams. An equation is presented that describes electromagnetic radiation propagation in plasma for the case in which the effects associated with charged separation and the occurrence of plasma waves can be disregarded. The electron concentration of the plasma is found analytically as a function of the intensity of the laser radiation field. The thermal mechanism underlying the occurrence of filamentation and self-focusing of radiation is analyzed. It is found that small-scale intensity perturbations (the filamentation process) can increase several fold under experimental conditions, and that significant self-focusing of laser beams is possible only when the heating radiation is significantly inhomogeneous. The role of filamentation and self-focusing becomes greater in larger-scale experiments. The striction mechanism of filamentation and self-focusing is dominant for Nd lasers; the contribution of the thermal mechanism is larger in experiments with lasers operating at shorter wavelengths. Figures 5; references 24: 18 Russian, 6 Western.

[438-6900]

## DYNAMICS OF CRYOGENIC LAYER IN TARGETS UNDER TEMPERATURE GRADIENT

Moscow KRATKIYE SOOBSHCHENIYA PO FIZIKE: SBORNIK in Russian No 1, Jan 85  
(manuscript received 14 Sep 84) pp 37-40

KORESHEVA, Ye. R. and NIKITENKO, A. N.

[Abstract] An experimental study was made of the dynamics of cryogenic layers in thermonuclear targets for fusion through compression by a laser beam, the purpose being to establish both temperature and time constraints on the transport of mass. The behavior of such a layer had already been found to depend largely on the temperature gradient around the target in a non-isothermal field. Tests performed with solid hydrogen  $n\text{-H}_2$ , solid deuterium  $n\text{-D}_2$ , and 1:1 hydrogen-deuterium mixtures inside microspherical glass shells have revealed that during laser action fuel is transported from high-temperature regions to the lowest-temperature region, also that the speed of transport increases as the mean target temperature becomes higher and as the temperature gradient becomes smaller. Transport of fuel from one half of the microsphere to the other was found to become appreciably slower at temperatures  $T < 10$  K for  $n\text{-H}_2$  and  $T < 12$  K for  $n\text{-D}_2$ . The results are interpreted on the basis of the kinetic theory of gases, assuming that the temperature difference across the inside surface of the cryogenic layer is very small relative to the mean absolute temperature of the target. Calculations based on the equation of steady-state heat conduction and its solution for boundary conditions of the fourth kind reveal a definite relation between the deviation of the temperature at any point on the inside surface from the mean temperature of the target and the measured outside temperature gradient, this relation depending on the ratio of thermal resistance to the gaseous layer to combined thermal resistance of the cryogenic layer and the shell wall. The thicknesses of both also influence that relation, unless they are both very small relative to the shell radius. On this basis can also be determined the maximum allowable time a cryogenic target can remain in a non-uniform temperature field without breaking down and the maximum allowable temperature gradient while focusing the laser beam on the target. Two possible ways to reduce the temperature gradient inside the target are to use a shell material with higher thermal conductivity, such as copper instead of glass, or to coat the glass with copper on the outside and to join the target structure to a high-resistance structure such as plastic foam or a vacuum cell. The authors thank I. A. Isakov and Yu. A. Merkulyev for support and valuable comments, V. M. Dorogotvtsev for assistance, Academician Yu. A. Osipyan for helpful discussions, and E. A. Shteynman for assisting with the experiments. Figures 2; tables 1; references 3: 2 Russian, 1 Western. [567-2415]

## CASCADING OF LASER SEPARATOR ELEMENTS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85  
(manuscript received 3 Jul 84) pp 1254-1260

VETSKO, V. M., DEVDARIANI, O. A., KLAITIN, S. A., KAMINSKIY, V. A.,  
LAGUNTSOV, N. I. and SULABERIDZE, G. A.

[Abstract] It has been experimentally demonstrated that the laser method can achieve unique values of elementary separation coefficient in isotope separation processes. This article studies sequential cascading of multiple stages of laser separator cells to determine the conditions under which high degrees of separation and utilization of target isotopes can be achieved. The separation characteristics of a laser cell are analyzed and the possibility is discussed of creating reactors and countercurrent sequences of separator cells. A study of the variation of optimal parameters of cells and sequences of cells as a function of such physical parameters as pressure and temperature, energy density, power density and laser radiation absorption coefficient is suggested. Figures 2; references 13: 8 Russian, 5 Western.  
[503-6508]

UDC: 533.95

## THERMONUCLEAR TARGET YIELD FOR HIGH POWER SHORTWAVE LASERS (WAVELENGTH NOT OVER 1 MICROMETER)

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85  
(manuscript received 25 Jul 84) pp 1289-1291

BASOV, N. G., GUS'KOV, S. Yu., DANILOVA, G. V., DEMCHENKO, N. N.,  
ZMITRENKO, N. V., KARPOV, V. Ya., MISHCHENKO, T. V., ROZANOV, V. B. and  
SAMARSKIY, A. A., Institute of Physics imeni P. N. Lebedev, USSR Academy  
of Sciences, Moscow

[Abstract] A study is made of the concept of achieving high gain factors in low entropy compression of thin microspheres at the level of moderate laser radiation flux density, up to  $10^{14}$  W/cm<sup>2</sup>. A technologically simple class of targets is studied, a spherical shell with an external ablator layer of polyethylene and an internal mass of DT ice. The parameters of the target are optimized in terms of gain. Computer programs are used which have been successfully applied in the past decade to solve problems of inertial synthesis and production of a pulse plasma. The results obtained in the calculations can be used to analyze the effectiveness of shortwave laser drivers for thermonuclear power systems. Figures 3, references 21: 16 Russian, 5 Western.  
[503-6508]

/9835



## OPTICS AND SPECTROSCOPY

### TEXTBOOK ON OPTICAL SYSTEMS THEORY MERITS AWARD NOMINATION

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 6 Sep 85 p 2

PROKHOROV, A., academician

[Excerpt] When talking to operators of the long-distance telephone exchange, residents of Gor'kiy have no notion that their conversations are being transmitted through an optical fiber instead of a conventional electric cable. Similar optical-fiber lines are operating in Moscow and Leningrad. They have appeared as a result of the creation of an optical and optoelectronic instrument-building industry.

The growing role of optical and optoelectronic instrument building in the acceleration of scientific-technical progress requires that skilled engineers and scientists be trained. Every year, higher schools of our country graduate hundreds of specialists in various fields of optics. Technical progress imposes rigid demands on the training of engineers.

Modern instructional literature, particularly in the newest branches of knowledge, is very important for radically improving the quality of training. Scientists B. Begunov, N. Zakaznov, S. Kiryushin and V. Kuzichev have written just such a textbook, which is essential for higher educational institutions as well as institutes for advanced training of specialists.

The textbook "Theory of Optical Systems" ("Teoriya opticheskikh sistem"), which has been published by the "Mashinostroyeniye" (machine building) publishing house, is written on a high ideological, scientific and methodological level. It ensures creative and active mastery of theoretical knowledge and practical skills by students. At an all-Union seminar for heads of chairs of instruction that train optics and optoelectronics specialists in fields where acute shortages of personnel exist, it was noted that this textbook meets new demands on the knowledge and qualifications of personnel. The textbook has been deservedly admitted to the competition for the USSR State Prize.

FTD/SNAP/9835  
CSO: 1862/041

# COMPUTER SIMULATION OF PROCESSES IN SOLID-STATE LASER OSCILLATORS AND AMPLIFIERS WITH PHOTOTUBE PUMPING: LASER PUMPING SYSTEMS

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P. N. LEBEDEVA  
in Russian Preprint No 105, 1984 KVANTOVAYA ELEKTRONIKA

GRADOV, V. M., KROMSKIY, G. I., MAK, A. A., SKLIZKOV, G. V., FEDOTOV, S. I.  
and SHCHERBAKOV, A. A.

[Abstract] Optical pumping systems for solid-state lasers are evaluated comparatively on the basis of a mathematical model of processes in them and the results of computer simulation. The principal criterion for comparison is the overall energy efficiency, assuming that two essential requirements are met: 1) a pumping power level adequate for attainment of the emission or amplification threshold; 2) uniform distribution of the pumping radiation density above the threshold level over the active medium. Radiative energy transfer through the pumping system with a discharge of radially nonuniform optical density is simulated by the method of discrete rays, adaptable to a specularly or diffusely reflecting mirror surface and to a specularly or diffusely refracting transparent surface. The method covers spherical and cylindrical surfaces, the general algorithm of solution of the corresponding integral and differential equations having been programmed for a self-consistent calculation of the pumping system characteristics. It is applied here to two fundamentally different pumping systems, where discharge produces an optically dense plasma and an optically thin plasma respectively. Analysis and calculations are particularized for several known variants of these pumping systems with various modes of laser emission tuning. First active tuning is considered, which involves absorption by the radiation plasma within the idle region or within the operating region of the activator's spectrum. Next is considered passive tuning, which involves absorption of radiation by passive laser components such as mirrors or filters. Analysis and comparative evaluation include plasma temperature and discharge losses in the tube walls as a function of the pumping system, and pumping system efficiency as a function of pumping power, mirror reflection mode and reflection coefficient, idle absorption of radiation within the pumping region of the spectrum, activator concentration, activator volume, stimulated filtration, absorption of radiation by the walls and the immersion medium, gas pressure in the discharge tube, tube diameter and vacancy level in the discharge channel. On the basis of these data the space distribution of pumping power absorbed by the active medium is determined and three requirements for approaching the conditions of an "ideal luminous boiler" are established, namely: 1) minimum active and

passive filtration of plasma radiation within the operating region of the activator's spectrum; 2) maximally amplified active filtration of plasma radiation within the idle region of the activator's spectrum; 3) maximum widening of the spectral range of active absorption by the active medium. Figures 24; tables 2; references 59: 49 Russian, 10 Western. [443-2415]

#### INFLUENCE OF LASER SYSTEM COMPONENTS ON RADIATION CONTRAST

Moscow VLIYANIYE ELEMENTOV LAZERNYKH SISTEM NA KONTRAST IZLUCHENIYA  
in Russian 1983 pp 1-30

NIKOLAYEV, F. A., SKLIZKOV, G. V., SOROKIN, V. V., STUKOV, O. I. and  
SHELOBOLIN, A. V., Physics Institute imeni P. N. Lebedev, USSR Academy of  
Sciences

[Abstract] This study analyzes the influence on laser radiation contrast of the components of the laser system: the saturable absorbers, the amplification stages, and the mirror systems that focus the radiation on the target. Also examined are the contrast properties of shutters employing the polarization principle, and the contrasts of the radiation of laser systems employing wave-front conjugation. Numerical estimates are made for the constructions and typical parameters of the components used in the Del'fin laser system. The analysis makes it possible to estimate the laser radiation contrast at any point in the optical circuit, including on the target. The findings allow contrast measurements at one point in the optical amplification circuit to be used to calculate the contrast values at other points in the circuit. Figures 7; references: 21 Russian. [438-6900]

#### OPTICAL PUMPING OF GAS LASERS BASED ON ELECTRON TRANSFER REACTION PROCESSES: REVIEW AND SUGGESTIONS

Moscow OPTICHESKAYA NAKACHKA GAZOVYKH LAZEROV NA OSNOVE PROTSESSOV  
FOTOPERENOSA ELEKTRONA: OBZOR I PREDLOZHENIYA in Russian 1983 pp 1-40

MIKHEYEV, L. D., Laboratory of Quantum Radiophysics, Physics Institute  
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[Abstract] This study integrates the material in the international literature on various optical methods for obtaining ion states, and examines a number of specific examples of the use of optical pumping to excite such states. The mechanism of broadband molecular absorption to excite lasing in gases is investigated. Work on direct optical excitation and photodissociation is reviewed. The role of harpoon reactions in the formation of ion states of molecules in excimer lasers is investigated. The review demonstrates the breadth of the possibilities of optical pumping, and makes it possible to

identify the directions that seem to hold promise for further research: the most important of these is direct optical excitation, and its concomitant secondary harpoon-type chemical processes. Using the example of molecular chlorine, it is shown that the search for working substances for direct optical pumping should not be restricted to heavy molecules. The importance of continuing the search for polyatomic excimers is stressed. Figures 5; references 83: 31 Russian, 52 Western.  
[438-6900]

#### INTERFERENCE OF RADIATION FROM TWO INDEPENDENT LASERS

Moscow OB INTERFERENTSII IZLUCHENIYA DVUKH NEZAVISIMYKH LAZEROV in Russian  
1983 pp 1-17

BYKOV, V. P. and SHEPELEV, G. V., Laboratory of Applied Hydrophysics,  
Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] Two interference experiments are described in which the possibility of lasing and the occurrence of significantly noncoherent macroscopic field states are investigated. The emission of active atoms when excited and non-excited states are superimposed is analyzed. The electrical field intensity of the laser radiation is calculated. The possibilities of observing the quantum states of the field is investigated experimentally. When the active atoms are fully excited at the initial moment, a field state with  $\langle E \rangle = 0$  can occur that is not the result of any averaging with respect to phase variables and that has no classical analog, and can be described only within the framework of quantum electrodynamics. Intermediate states are also possible in which the radiation field is characterized by non-zero intensity, but its magnitude is smaller than the classical value and is determined by the degree of superposition of the working levels. Figures 2; references 19: 8 Russian, 11 Western.  
[438-6900]



INFLUENCE OF COHERENCE OF RADIATION FROM INJECTION LASERS ON FORM OF  
CORRELATION SIGNAL IN MATCHED OPTICAL SPATIAL FILTERING CIRCUIT. PART 2.

Moscow VLIYANIYE KOGERENTNOSTI IZLUCHENIYA INZHEKTSIONNYKH LAZEROV NA FORMU  
KORRELYATSIONNOGO SIGNALA V SKHEME SOGLASOVANNOY OPTICHESKOY PROSTRANSTVENNOY  
FILTRATSII in Russian 1983 pp 2-30

ZOLOTAREV, A. I., KALASHNIKOV, S. P. and MOROZOV, V. N., Physics Institute  
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[Abstract] The influence of the degree of coherence of the radiation produced by injection lasers on the form of the output signal of an optical correlator is investigated. The object of the study was the classical Van der Lugt matched optical filter-correlator. As the ratio of the angle of coherence of the radiation to the angular dimension of the object becomes smaller, the signal/background value of the correlation response drops monotonically in the interval between the extreme values, which determine the result of the correlation of the object with respect to the amplitude coefficients of transmission and with respect to intensity. The limiting value of the signal/background ratio corresponding to the noncoherent case is reached when the size of the coherent region of the radiation in the plane of the object is equal to the spatial period of the object. The findings can be used to select the proper type of injection laser and to determine its optimum operating mode, as well as the geometric parameters of the recording and processing circuits to provide maximum density of the process information with lax requirements for the filter adjustment accuracy. Figures 11; references 26: 21 Russian, 5 Western.  
[438-6900]

CONSTRUCTION PRINCIPLES AND OPTICAL SCHEMES FOR AMPLIFYING, FORMING, AND  
FOCUSING RADIATION FROM THE MIKRON LARGE-SCALE RECTANGULAR NEODYMIUM GLASS  
LASER SYSTEM

Moscow PRINTSIPY KONSTRUKTSII I OPTICHESKIYE SKHEMY USILENIYA,  
FORMIROVANIYA I FOKUSIROVKI IZLUCHENIYA LAZERNOY USTANOVKI "MIKRON" NA  
KRUPNOGABARITNYKH NEODIMOVYKH STEKLAKH PRYAMOUGLONNOY FORMY in Russian 1983  
pp 1-34

BUFETOV, N. A., YERSHOV, V. V., KRAVTSOV, C. B., PIMENOV, Yu. I.,  
SPIRIDONOV, V. A., FEDOROV, V. V. and FOMIN, V. K., Oscillations Laboratory,  
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[Abstract] Amplification of single laser pulses in rectangular active elements in the Mikron neodymium glass laser system is investigated. The optical-mechanical circuits and construction of the amplifier are investigated, and the optical pumping system is described in detail. Experimental findings obtained in the free lasing mode are presented that demonstrate the capabilities of the system. Focusing of the radiation produced by the multi-channel system is described. The best optical scheme for amplification is



found experimentally to consist of blocks of light sources that make it possible to obtain output energy of up to 6 kJ in pulses 70 nsec long. A method is described for combining the laser radiation from the separate channels into a single beam and focusing the radiation. The system is shown to be capable of supporting several experiments simultaneously. Figures 10; references 22: 20 Russian, 2 Western.  
[438-6900]

UDC 621.373.826.038.823

#### SELECTION OF DIFFRACTION GRATING FOR TUNABLE CO LASER

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 3, Mar 85  
(manuscript received 16 Dec 83) pp 60-61

VASILYEV, A. V., PLOTNICHENKO, V. G., SYSOYEV, V. K. and MASYCHEV, V. I.

[Abstract] The spectral behavior of the coefficients of reflection and optical losses of various diffraction gratings employed in tunable CO lasers are investigated. The relationship between these parameters and the energy characteristics of tunable CO lasers is established. The reflection spectra of the diffraction gratings are measured by means of an IKSV-1 automated system employing a modified IPO-76 attachment. Diffraction gratings with 100, 150, and 300 lines per millimeter, blaze angles ranging from 5 to 6  $\mu$ m and gold and aluminum reflecting coatings on glass, invar and aluminum substrates. The losses measured from specimen differ significantly. The optimum grating for obtaining the greatest lasing power in a tunable CO laser is found to be a gold-coated grating on an invar base with 150 lines per millimeter and reflection coefficient of 89%.

Figures 2; references 5: 1 Russian, 4 Western.

[427-6900]

UDC 520.2

#### POSSIBILITY OF DEVELOPING LARGE LIGHTWEIGHT METAL MIRRORS FOR LONG-WAVE IR REGION OF SPECTRUM

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 3, Mar 85  
(manuscript received 16 Apr 84) pp 13-16

VITRICHENKO, E. A., YEVSEYEV, O. A., ISAYEV, V. I., LAPSHIN, V. I., LEONOV, V. N., POTAPOV, Yu. A., PROKHOROV, A. M., SAGDEYEV, R. Z., SALOMONOVICH, A. Ye., TRUSHIN, Ye. V. and FRIDLYANDER, I. N.

[Abstract] The possibility is investigated of developing large mirrors approximately 1 m in diameter for use in the long-wave infrared and sub-millimeter bands for astronomical experiments outside the atmosphere. A

new aluminum alloy--V96ts1--which provides good strength and anticorrosion properties and can be worked by traditional optical methods is employed. The milling, grinding, and polishing of the metal mirror are described. Tests made immediately after optical treatment, and then several times over the following four weeks, revealed no changes in the shape of the mirror. Figures 4; references 17: 14 Russian, 3 Western.  
[427-6900]

UDC 535.361.2

#### DETERMINATION OF ROUGHNESS PARAMETERS OF METAL MIRROR USING SF-18 SPECTROPHOTOMETER

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 3, Mar 85  
(manuscript received 2 Dec 83) pp 41-45

MAZURENKO, M. M., SKRELIN, A. L. and TOROPETS, A. S.

[Abstract] An SF-18 spectrophotometer is used to investigate the diffuse and total flux reflected by the surface of metal mirrors as a function of wavelength. Mirrors made of tin, and of steel, coated with a gold layer, of fused quartz coated with vacuum-deposited aluminum, of copper, and of bronze-zirconium alloy are investigated. The measured parameters of the specimens are calculated. It is found that 98% of the diffuse reflected flux is determined by the fine-structure component resulting from microscopic irregularities. Figures 4; tables 2; references 5: 4 Russian, 1 Western.  
[427-6900]

UDC 621.375.8

#### SELECTION OF OPTIMUM RESONATOR FOR ATTAINMENT OF DIFFRACTIONALLY DIRECTIVE RADIATION FROM ELECTRICALLY IONIZED POWER-PULSE CO<sub>2</sub>-LASERS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 283, No 5, Aug 85  
(manuscript received 20 Dec 84) pp 1177-1180

BASOV, N. G., academician, DANILYCHEV, V. A., ZVORYKIN, V. D., LESNOV, I. A., RUDOY, I. G. and SOROKA, A. M., Institute of Physics imeni P. N. Lededev, USSR Academy of Sciences, Moscow

[Abstract] The maximum attainable directivity of radiation from electrically ionized CO<sub>2</sub>-lasers with a large volume of an optically homogeneous medium, and usually with an unstable telescopic resonator ensuring emission in a single transverse mode, is limited by large-scale nonuniformity of the density distribution owing to dynamic gas flow and by small-scale nonuniformity of

the density distribution owing to dynamic gas flow and by small-scale non-uniformity of optical properties owing to variations of the radiation field amplitude inside such a resonator. An experimental study of such a laser was made which included measurement of the divergence angle of the light beam as well as the equivalent Fresnel number and the resonator magnification depending on the resonator parameters: diameters of its two mirrors and their radii of curvature. The purpose was to establish the feasibility of reaching the diffraction limit of divergence. The resonator length was varied by holding the larger mirror at a fixed distance of approximately 50 cm from the active cell and moving the diffracting smaller mirror along the axis. With an energy input of approximately 140 J/ℓ·atm, emission pulses of 60 J energy and 3 μs duration were generated almost independently of the resonator dimensions. Parasitic effects were eliminated by making the resonator aperture smaller than the discharge gap. Measurements and oscillograms revealed that sufficiently long resonators,  $L = 5-10$  m with a typical magnification  $M = 1.4$ , had produced radiation patterns similar to a Fraunhofer diffraction pattern, with the intensity of higher-order diffraction side peaks increasing and eventually exceeding that of the center peak as the resonator length was decreased to  $L = 2.5$  m. Better directivity was obtained, however, not only by increasing the resonator length but also by increasing its magnification to  $M \sim 2$  at any length. The authors thank I. V. Kholin and N. N. Ustinovskiy for making available the laser facility, also V. V. Trofimenko and A. G. Yarova for assistance in preparing the experiment. Figures 3; references 8: 4 Russian, 4 Western. [583-2415]

#### SMALLER ATTENUATION OF GAUSSIAN THAN OF PLANE HELICONIC BEAMS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 19, No 7, Jul 85 (manuscript received 19 Nov 84, signed to press 12 Feb 85) pp 1305-1308

YANKAUSKAS, Z. K. and TOLUTIS, R. B., Vilnius Institute of Civil Engineering

[Abstract] Gaussian heliconic beams in magnetized semiconductor plasmas are preferable to plane ones because of their exponential ( $e^{-r^2/w^2}$ ) and thus much smaller attenuation with increasing distance from the center, which makes a narrow beam pass a much thicker plate than will a wide beam. The smaller attenuation is attributable to anisotropy of the electrical resistivity of magnetized plasmas, as has been demonstrated experimentally on plates of InSb. Theoretical interpretation of this evidence is based on the applicable field equations in the approximation of a negligible current attenuation in a strong external magnetic field, where all three vectors of a heliconic beam (current, magnetic field, electric field) are expressible through the same one scalar function. Analysis of the energy relations and calculation of the attenuation decrement for the radially symmetric mode, with numerical evaluation for the two extreme cases of a beam width respectively much larger and much smaller than the wavelength, indicate an advantage of a Gaussian beam by a factor of 3.4 with relaxation of electrons and their scattering by impurities taken into account. This is

confirmed by data pertaining to a 2 cm thick InSb plate with electron concentration  $n = 1.5 \cdot 10^{16} \text{ cm}^{-3}$  and electron mobility  $\mu_e = 7.5 \text{ m}^2/(\text{V} \cdot \text{s})$ , at 20°C temperature and over the 50-300 MHz frequency range in a magnetic field of the order of 1 T. References 6: 5 Russian, 1 Western (in Russian translation).  
[595-2415]

UDC 532.528

#### MEASURING CONCENTRATION OF ABSORBING ATOMS BY INTRACAVITY LASER SPECTROSCOPY

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA in Russian Vol 18, No 3, Aug 85 (manuscript received 9 Oct 84) pp 87-90

ASHURBEKOV, N. A., YEGOROV, V. S. and BORISOV, V. B.

[Abstract] This study describes the use of intracavity laser spectroscopy to measure the concentration of excited atoms in a discharge by measuring the total absorption within the cavity at the transition in question. Expressions are derived for the connection between total absorption within the cavity and the concentration of absorbing particles. A pulse discharge in neon is investigated experimentally, and the populations of the  $2p^5 3s^3 P_2$  and  $2p^5 3p^3 P_1$  states in the pulse discharge afterglow are measured. Figures 2; references: 6 Russian.  
[70-6900]

UDC: 621.373.826

#### THEORETICAL MODEL OF PHOTOSTIMULATED COMBUSTION OF DISPERSED MEDIA IN AN OPTICAL RESONATOR

Kiev KVANTOVAYA ELEKTRONIKA in Russian No 28, 1985  
(manuscript received 15 Nov 83) pp 14-24

BARMASHENKO, B. D., Institute of Semiconductors, Ukrainian Academy of Sciences, Kiev

[Abstract] A study is made of combustion of droplets in an oxidizer. It is assumed that droplet radius is much less than wavelength of radiation generated by combustion so that scattering of radiation on droplets can be ignored. Radiation losses within the resonator are thus related primarily to absorption by droplets. The energy of absorbed photons is expended in evaporation of the droplets. The evaporated fuel then reacts with the oxidizer, leading to the formation of excited molecules which, in the case of high photon density in the resonator emit new photons. If the absorption by the droplets significantly exceeds losses in the mirrors,



photons may accumulate in the resonator. This results in photostimulated combustion of the dispersed mixture. The process becomes selfaccelerating and the combustion time of the droplets is significantly reduced in comparison to ordinary combustion. The energy of the coherent radiation generated becomes a significant fraction of the chemical energy liberated in the reaction. The theoretical model of the process developed in this article allows determination of threshold conditions for development of lasing in the medium, as well as the variation of mixture and radiation power parameters with time for steady and unsteady generation conditions. References: 4 Russian.  
[048-6508]

UDC: 535.36

#### INFLUENCE OF DIFFRACTION ON FORCED RAMAN RADIATION OF LIGHT BEAMS IN A RESONATOR

Kiev KVANTOVAYA ELEKTRONIKA in Russian No 28, 1985  
(manuscript received 21 Nov 83) pp 24-31

DOVGIIY, B. P., MARCHEVSKIY, F. N. and STRIZHEVSKIY, V. L., Kiev State University imeni T. G. Shevchenko

[Abstract] A study is made of the influence of aperture and diffraction effects on output parameters of Raman lasers based on numerical solution of wave parabolic equations for the interacting waves in a Raman-active medium placed within a resonator with plane parallel mirrors. Threshold generation conditions as influenced by diffraction losses are determined, as are the energy characteristics of the generation process. A numerical experiment is performed by simple iteration using the equations derived in the article and results are achieved which can be useful in the interpretation of experimental data and optimization of output parameters of Raman lasers. Figures 3; references: 7 Russian.  
[048-6508]

UDC 535.417

#### TALBOT-EFFECT INTERFEROMETRY OF COMPOUND MIRRORS

Moscow KRATKIYE SOOBSHCHENIYA PO FIZIKE: SBORNIK in Russian No 1, Jan 85  
(manuscript received 13 Jul 84) pp 3-6

KORYAKOVSKIY, A. S., MARCHENKO, V. M. and PROKHOROV, A. M.

[Abstract] Interferometry of compound mirrors by the Talbot method is analyzed and evaluated, inasmuch as this method involves not only angular alignment of the reflector elements but also determination of their surface profiles and detection of distorting wavefront discontinuities equivalent to



phase jumps due to relative shifting along the optical axis. Numerical calculations on the basis of the Fresnel-Kirchhoff theory are made for a coherent monochromatic parallel light beam which passes through a two-dimensional periodic grating before impinging on a mirror in the plane of reconstruction and is then recorded in a plane of reconstruction behind that mirror. A comparison of the calculated and measured intensity distributions in the planes of reconstruction, with the distance between mirrors varied, reveals that symmetry of these distributions with respect to the site of a phase jump is an indicator of their common phase. This suggests an alignment procedure which involves superposition of reconstructed patterns and of light spots at narrow diffraction edges appearing as a result of interference of higher-order harmonics between edges of adjacent reflector elements. Both procedure and equipment can be automated. Operation with nonmonochromatic light or at a wavelength other than that at which the mirror has been aligned requires absolute phasing rather than phasing within a whole number of wavelengths only. Figures 1; references 6: 3 Russian, 3 Western (1 in Russian translation).

[567-2415]

#### AUGER-PROFILES OF COMPOSITION AND LUMINESCENCE INVESTIGATIONS OF LIQUID-PHASE InGaAsP HETEROSTRUCTURES WITH $(1.5-5) \cdot 10^{-6}$ cm ACTIVE REGIONS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 19, No 6, Jun 85 (manuscript received 31 Jan 85) pp 1108-1114

ALFEROV, Zh. I., GARBUZOV, D. Z., ARSENT'EV, I. N., BER, B. Ya., VASILOVA, L. S., KRASOVSKIY, V. V. and CHUDINOV, A. V., Physical-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] A method developed previously by the authors for obtaining InGaAsP/GaAs and InGaAsP/InP heterostructures is investigated, and data from Auger spectrometric and luminescent investigation pertaining to determining the thickness of the active region and the composition distribution profile in those structures, is presented. A modified liquid-epitaxy method is described that makes it possible to obtain heterostructures in which the thickness of the active region is limited only by the widths of the transitional regions at the heteroboundaries. The transitional regions are found to have no significant effect on luminescent characteristics at room temperature. Comparison with Auger-spectrometry findings confirms that the luminescence method for determining the thickness of superthin active regions is valid. Figures 2; references 15: 10 Russian, 5 Western.

[525-6900]

## OPTIMIZATION OF PASSIVE MODE LOCKING OF YTTRIUM ALUMINATE LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 5, May 85  
(manuscript received 20 Dec 83) pp 718-723

DEMCHUK, M. I., MIKHAYLOV, V. P., GULEV, A. K., ISHCHENKO, A. A.,  
KUDINOVA, M. A., SLOMINSKIY, Yu. L. and TOLMACHEV, A. I.

[Abstract] Passive mode locking is investigated in an yttrium aluminate laser incorporating a number of specially selected passive shutters based on solid- and liquid-phase saturable absorbers. The experimental setup employed a semiconfocal-cavity laser stabilized by pumping a dye solution through the system. Dyes 3281 and 3321, or dyes with smaller bleaching strength, are found to be optimal. An ultrashort pulse length of 5 picoseconds is achieved, with significantly shorter than the shortest ultrashort pulse obtained by the authors on a YAG laser (22 psec). The power of a single pulse without additional optical amplification is approximately 0.4 GW. It is found that different pulse shapes can be obtained by varying the bleaching intensity and relaxation time. The energy distributions of the ultrashort pulses for different operating frequencies are found to be significantly more stable than for a YAG laser employing the same thin-film passive shutter. Table 1; figure 1; references 10: 7 Russian, 3 Western.

[512-6900]

## INVESTIGATION OF LASING AND RESOURCE CHARACTERISTICS OF ACTIVE ELEMENTS OF TAPE LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 5, May 85  
(manuscript received 5 Dec 83) pp 723-727

SKRINKO, G. A., SENDER, V. P., ZOLOTAREVA, L. Ye., KONDRATYUK, N. V. and  
SHAGOV, A. A.

[Abstract] The spectral-luminescent, lasing, and resource characteristics of active tape lasers based on cellulose diacetate and polyvinylethylal. The active tapes were obtained from a polymer solution in the appropriate solvent, to which a dye solution was added. Tapes activated by dyes of the coumarin, rhodamine and oxazine groups were investigated. The characteristics of the absorption and luminescence spectra of the activated tapes are tabulated, indicating that luminescence spectra of most dyes in diacetate are broader than for ethanol solutions, with the maxima moving to the long-wave region. The broadening was found spectroscopically to be irregular. The resource characteristics of cellulose diacetate elements are found to be significantly better than for polyvinylethylal, indicating that the

resource characteristics of tunable tape lasers are determined by the resource of the active element in the long-wave region of the lasing spectrum. The effects noted can be used to form high performance lasing tracks on active tapes. Tables 2; figures 5; references 5: 4 Russian, 1 Western.  
[512-6900]

UDC 621.373.826:621.384.3

FAST IR SPECTROPHOTOMETER WITH AUTOMATED SYSTEM FOR DETERMINING PARAMETERS OF WORKING MEDIA OF FLOW-THROUGH MOLECULAR LASERS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 5, May 85  
(manuscript received 1 Dec 83) pp 727-734

BAKHIR, L. P., LEVASHENKO, G. I., MAZAEV, N. V., KATSEVICH, S. P. and SHURALEV, S. L.

[Abstract] An automated IR spectrophotometer is described that can be used to measure the spectral luminosity and absorption of the medium in question at 0.5-5.5  $\mu\text{m}$  by modulating the radiation of the bleaching source and the medium at different frequencies. The methods and equipment developed make it possible to obtain substantial information on the parameters of the state of active media of  $\text{CO}_2$  lasers, and to reach conclusions regarding the sources and amount of loss of laser radiation, to assess the effectiveness of different pumping systems, and to judge the characteristics of the kinetic processes occurring. The functional diagram of the automated spectrophotometer is traced and explained. The automated data processing system consists of an analog-digital conversion and interface device, an Elektronika DZ-28 computer, and a thermal printer. The high speed spectrophotometer can also be used to investigate active media employed in CW lasers. Figures 4; references 7: 6 Russian, 1 Western.  
[512-6900]

UDC 621.375.8

INTRA-CAVITY MAGNETOOPTICAL CONTROL OF RADIATION INTENSITY OF GAS LASER WITH HIGH-GAIN ACTIVE MEDIUM

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 5, May 85  
(manuscript received 31 Oct 83) pp 734-739

DEM'YANTSEVA, S. D., KOSITSYN, B. Ye., and TABARIN, V. A.

[Abstract] Intra-cavity amplitude-modulation in a high-gain gas laser is investigated on the basis of the balance equations of lasing theory, making it possible, using boundary conditions, to investigate concentrated controlled

losses, which corresponds more nearly to the physical conditions for internal modulation than do distributed losses. Formulas are obtained for finding the influence of amplitude anisotropy, the coefficients of reflection of the mirrors, and the gain of the active medium on the static characteristics of amplitude modulation. The upper bound for which the gain can exceed the losses is established. Figures 3; references 12: 8 Russian, 4 Western.

[512-6900]

UDC 535.361.2

LINEAR ESTIMATION OF PARAMETERS OF AEROSOL MICROSTRUCTURE FROM SPECTRAL MEASUREMENTS OF SCATTERED RADIATION CHARACTERISTICS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 5, May 85  
(manuscript received 27 Feb 84) pp 820-824

CHAYKOVSKIY, A. P. and SHCHERBAKOV, V. N.

[Abstract] The possibility of linear estimation of the microstructural parameters of an aerosol by data from spectral measurements of scattered radiation characteristics is investigated. An approach for finding the linear estimation coefficients is presented whose accuracy can be enhanced by taking into account the a priori correlation function of the dimension distribution spectra. The capabilities of the proposed approach are demonstrated by estimating the aerosol concentration by volume using data from measurements of the backscattering coefficients at two different wavelengths. Even with a limited number of measurements, the linear estimation method makes it possible to determine important microphysical parameters with satisfactory accuracy. The approach is convenient from the viewpoint of optimal experimental design, as well as investigation of the influence of different aerosol fractions on the estimation error.

Figures 1; references 9: 6 Russian, 3 Western.

[512-6900]

UDC 535.36:778.6

COMPARISON OF PRECISE AND APPROXIMATE METHODS FOR CALCULATING COEFFICIENTS OF TRANSMISSION AND REFLECTION OF LIGHT FOR PLANE LIGHT-SCATTERING LAYERS CONSIDERING INDEX OF REFRACTION

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 5, May 85  
(manuscript received 1 Aug 83) pp 825-828

BAZHIN, N. M. and KUZNETSOV, C. V.

[Abstract] A comparison is made of the calculation of the integral coefficients of reflection and transmission of plane light-scattering layers



with normal illumination using the Monte Carlo method on the one hand, and two-stream, two-parameter approximation and diffusion approximation on the other. The comparison makes it possible to judge the possibility of using approximate formulas for the integral coefficients of reflection and transmission. Reflection from the boundaries is described by Fresnel's formulas in the Monte Carlo method; Lambert's law describes the reflection from boundaries in the two-parameter approximation method. The integral values of the coefficients of reflection are the same for both methods. The coefficients of reflection and transmission found with the help of the approximate method are in satisfactory agreement with the results of exact calculation; consequently, the two-parameter and diffusion approximation methods can be used in a number of applications to estimate the values of the integral coefficients of reflection and transmission for media with index of refraction of other than unity. Tables 2; references 6:

5 Russian, 1 Western.

[512-6900]

UDC 535.36

#### USE OF RADIAL DISTRIBUTION FUNCTION TO ANALYZE LIGHT SCATTERING IN DISPERSE MEDIUM

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 5, May 85  
(manuscript received 1 Aug 83) pp 828-834

LOYKO, V. A., IVANOV, A. P. and DIK, V. P.

[Abstract] This study describes a theoretical approach to analyzing the characteristics of light scattering resulting from correlation of the position of the particles in the scattering medium. The combined influence of the correlation of the arrangement of the particles and their mutual re-irradiation is investigated experimentally for a broad range of scattering angles. A structural factor  $S$  is introduced that characterizes the difference of the scattering index of two types of media caused by correlation of the particle arrangement. The use of the radial distribution function and the structural factor makes it possible to characterize quantitatively a dense medium, to determine the degree of deviation of the particle distribution statistics from random, and thus to judge the possibility that cooperative effects will be manifested in the scattered radiation. Figures 5; references 10; 4 Russian, 6 Western.

[512-6900]



## EXPERIMENTAL INVESTIGATION OF CHARACTERISTICS OF RADIATION REFLECTED BY SEMIINFINITE SCATTERING MEDIUM

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 5, May 85  
(manuscript received 14 Sep 82 after revision) pp 834-839

VOYSHVILLO, N. A.

[Abstract] The characteristics of radiation reflected by a semiinfinite scattering medium are investigated experimentally for oblique angles of incidence of the illuminating beam and with significant absorption in the medium. The luminence factor, the angular behavior of the luminence factor, and the coefficient of reflection are investigated. It is found that the absorption in the glass increases as the scattering angle luminence of the reflected light increases. The theoretical investigations show that the coefficient of diffuse reflection exceeds the coefficient of reflection; these two figures are the same only for  $\Lambda=1$ . Figures 1; references 20: 16 Russian, 4 Western.

[512-6900]

## LASING CHARACTERISTICS OF LASER WITH IDENTICAL MIRROR REFLECTION COEFFICIENTS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 5, May 85  
(manuscript received 10 Oct 83) pp 857-860

KOTOMTSEVA, L. A., LOYKO, N. A. and SAMSON, A. M.

[Abstract] Steady-state high frequency radiation pulsations in a linear laser with identical mirror reflection coefficients are investigated. The behavior of the amplitude, whose role in forming the change in the intensity picture over time is decisive, is analyzed. Radiation pulsations are found to result from the coherent properties of the active medium and the generated field. A region of existence of pulses with period  $T/s$  is superimposed on the area of development of pulsations with period  $T$ ; when these regions overlap, hysteresis and irregular undamped pulsations become possible. Figures 2; references: 3 Russian.

[512-6900]

## ACOUSTOOPTICAL-REFLECTOR TUNING OF DISTRIBUTED FEEDBACK DYE LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 5, May 85  
(manuscript received 11 Jan 84) pp 860-861

DERYUGIN, I. A., D'YACHKINA, A. V., KOSTENICH, Yu. V., RUBINOV, A. I.,  
TALALAYEV, M. A. and EFENDIYEV, T. Sh.

[Abstract] This study describes the use of an acoustooptical reflector to control the wavelength of a distributed feedback dye laser employing a 90-degree triangular glass prism with one of its lateral facets in contact with the dye solution. The pumping radiation, formed in a strip running perpendicular to the edge of the prism, was directed toward the hypotenuse facet, where it was refracted and split into two complementary beams. An acoustooptical reflector was employed to change the angle of incidence of the pumping radiation on the surface of the prism, thus changing the wavelengths of the laser. The experiments demonstrate the possibility of controlling the wavelength of distributed feedback lasers simply with the help of acoustooptical reflectors. Figures 1; references 3: 2 Russian, 1 Western.

[512-6900]

## PLOTING PHONON SPECTRA OF HEXAGONAL CdS AND CdSe ON BASIS OF THERMAL SCATTERING OF X-RAYS

Vilnyus LITOVSKIY FIZICHESKIY SBORNIK in Russian Vol 25, No 3, May-Jun 85  
(manuscript received 12 Jul 84) pp 54-63

PURLIS, R. P., Vilnyus State University imeni V. Kapsukas, and  
YAKIMAVICHYUS, I. A., Vilnyus Institute of Structural Engineering

[Abstract] The temperature-dependent intensity of thermal scattering of x-rays in hexagonal high-resistivity CdS and CdSe single crystals was measured, the purpose being to extract the one-phonon component for plotting the wave-vector distributions of rms dynamic displacements and of frequencies in these materials. Scattering by longitudinal lattice vibrations and by transverse lattice vibrations was measured according to the respective procedure, ensuring a reflection angle always equal to the incidence angle in the first case and varying both angles in the second case. The scattering intensity was measured on both sides of lattice nodes and the readings were then averaged. The intensities of first-order, second-order, n-order scattering  $I_T = I_T^1 - I_T^2 - I_T^n$  were calculated as the differences between intensities of Compton scattering and diffuse scattering in each order. With the temperature dependence of structural parameters characterized by the Debye-Valler factor the temperature dependence of the scattering intensity

yields a linear relation from which one-phonon scattering and two-phonon scattering can be separated, the two components in the harmonic approximation being proportional to rms dynamic displacements in the first degree and in the second degree respectively. The results indicate an appreciable contribution by two-phonon scattering to the total intensity of thermal scattering and a significant effect of optical modes, excited to higher degrees with rising temperature, on the distributions. Next are plotted the branches of phonon spectra corresponding to acoustic frequencies and optical frequencies respectively, separation of those being facilitated by the interrelation between elements of the scattering matrix and those of the dynamic matrix. The corresponding rms dynamic displacements and frequencies are calculated numerically for CdS and CdSe, on the basis of known data and established dependence on the intensity of one-phonon scattering. Figures 7; tables 1; references 20: 8 Russian, 12 Western (4 in Russian translation). [39-2415]

UDC: 621.373.826

#### NOISE IN FOUR-WAVE HYPERSONIC INVERTING MIRRORS UNDER ABSOLUTE INSTABILITY CONDITIONS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85  
(manuscript received 25 Jun 84) pp 1184-1190

MATVEYEV, A. Z., Institute of Applied Physics, USSR Academy of Sciences, Gor'kiy

[Abstract] The use of four-wave hypersonic inverting mirrors allows achievement of high coefficients of reflection of a weak signal, the minimum level of which is determined only by the internal noise in the nonlinear medium. An important question is that of the sensitivity of these mirrors under absolute instability conditions. This article calculates the noise of such a mirror under these conditions in the pumping wave fixed field approximation, demonstrating that sensitivity deteriorates above the instability threshold. Figures 2; references: 4 Russian. [503-6508]

## SYNCHRONIZATION OF LASER MODES UPON INTERACTION WITH RESONANT MEDIUM WITH SPLIT LEVEL

MOSCOW KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85  
(manuscript received 4 Jul 84) pp 1227-1234

KOCHAROVSKAYA, O. A., KHANIN, Ye. I. and TSAREGRADSKIY, V. B., Institute of Applied Physics, USSR Academy of Sciences, Gor'kiy

[Abstract] A study is made of the interaction of modes in a laser with a nonlinear filter to answer the question of the possibility of synchronizing laser modes by means of the coherent nonlinearity of 3-level media. The interaction of the 3-level medium with multimode radiation having quasi-equidistant frequency spectrum is observed. The mode synchronization mechanism discussed is achieved in a series of narrow frequency intervals when the split-level frequencies coincide with any of the intermode frequencies with an accuracy equivalent to the width of the spectral line of the low-frequency transition. The synchronization mechanism differs from saturating absorption and places no limiting conditions on the rate of relaxation of the population difference. References 13: 5 Russian, 8 Western.  
[503-6508]

INFLUENCE OF SELF-ACTION EFFECT ON FIELD STRUCTURE OF ELECTROIONIZATION CO<sub>2</sub> LASER WITH UNSTABLE RESONATOR

MOSCOW KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 6, Jun 85  
(manuscript received 19 Jul 84) pp 1285-1288

DIMAKOV, S. A., PEL'MENEV, A. G., PETROV, V. F., SHERSTOBITOV, V. Ye. and YASHUKOV, V. P.

[Abstract] An experimental study demonstrates that small scale heterogeneities in a medium lead to a significant change of the distribution of radiation intensity over the surface of the mirror of an unstable resonator during the course of the pulse. The experiments utilized an electroionization laser with an active volume of 1.5 l, CO<sub>2</sub>:N<sub>2</sub>:He=1:2:3, pressure 1 atm, pumping pulse length 28 microseconds, energy 300 J/l. During the course of a laser pulse the structure of the lower mode changes, with individual hot spots developing at certain moments in time in which the intensity of radiation is significantly greater than the average. This occurs not only in the first peak but also later in the pulse. This alteration of the amplitude structure of the mode is accompanied by a change in the shape of the wave front, all of which leads to deterioration in directivity of radiation. Figures 3; references 11: 9 Russian, 2 Western.  
[503-6508]

RADIATION CHARACTERISTICS OF PLANE LAYER OF STRONGLY SCATTERING WEAKLY  
ABSORBING MEDIUM WITH ARBITRARY REFLECTION FROM BOUNDARIES

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 23, No 2, Mar-Apr 85  
(manuscript received 8 Jun 83) pp 346-355

STEPANOV, S. V. and BERKOVSKIY, M. A., Institute of High Temperatures, USSR  
Academy of Sciences

[Abstract] Asymptotic expressions are derived for the hemispherical directional reflecting and transmission properties for any type of reflection and transmission occurring with highly dispersed solid materials on whose boundaries the index of refraction changes abruptly. A modified diffusion approximation is used that is accurate to within a factor depending upon the optical properties of the front boundary and the bulk scattering index. Formulas are presented that make it possible to disregard surface optical properties in solving a number of problems in the spectroscopy of strongly scattering weakly absorbing media. Cases are presented in which the corresponding asymptotes exhibit a closed form. Figures 1; references 14: 11 Russian, 3 Western.  
[420-6900]

## USE OF SYNTHESIZED FILTERS IN AN OPTICAL SYSTEM FOR PATTERN RECOGNITION

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 11, No 8,  
26 Apr 85 (manuscript received 13 Dec 84) pp 487-490

ILIYEVA, M. G., Bulgarian Academy of Sciences, Central Laboratory for  
Optical Recording and Processing of Information, Sofia

[Abstract] The purpose of this work was to select an optical filtering system which can be used to classify an unknown input into a given class within which the difference can be defined among various objects. Four filters were synthesized by digital modeling of a generalized Fourier transform for each object in the class. The method of synthesis is described. The filters were used to perform studies in a coherent optical system for 3-dimensional filtration. The energy distribution as a function of distance in centimeters from the optical axis is diagrammed. It is found that four photo receptors located at defined points are sufficient for the pattern recognition desired. The use of these synthesized filters in optical systems allows input information to be encoded by sensitive compression of information volume. Figures 2; references: 2 Russian.  
[508-6508]



STUDY OF INJECTION BRAGG LASER WITH HIGH TEMPERATURE STABILITY OF RADIATION  
WAVE LENGTH

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 11, No 9,  
12 May 85 (manuscript received 21 Feb 85) pp 524-530

GUREVICH, S. A., KARPOV, S. Yu., NESTEROV, S. I., PORTNOY, Ye. L., SKOPINA, V. I.  
and TIMOFEYEV, F. N., Physical-Technical Institute imeni A. F. Ioffe, USSR  
Academy of Sciences, Leningrad

[Abstract] A study is made of a monolithic-hybrid Bragg laser operating in the lowest first order of diffraction. Optimal matching of the amplifying semiconductor waveguide with a dielectric waveguide, the Bragg reflector, is also performed. To find the optimal matching conditions, the field distribution in a semiconductor waveguide and corrugated dielectric waveguide are computed, as well as the mode conversion coefficient at the junction of the waveguides. Transition to distributed reflection of light in the first order of diffraction can decrease optical losses in the Bragg mirror and allows direct experiments on observation of Bragg reflection bands.

Figures 4; references 8: 6 Russian, 2 Western.  
[509-6508]

UDC: 535.36

A NEW METHOD OF PARAMETRIZING THE RADIATION SCATTERING INDEX IN SPATIALLY  
LIMITED SCATTERING MEDIA

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 55, No 6, Jun 85  
(manuscript received 15 Jun 84; in final form 13 Nov 84) pp 1184-1186

SAVEL'YEV, B. A., LARIONOV, V. V., GORYACHEV, B. V., MOGIL'NITSKIY, S. B.,  
and KUTLIN, A. P., Tomsk Polytechnical Institute imeni S. M. Kirov

[Abstract] The purpose of this work was to establish the relationship between parameters of scattering index and scattering medium and to create a method of solving reverse problems, such as determination of the scattering index. Parametrization of the scattering index as here suggested allows a great reduction in the volume of experimentation and computation required, and represents a unique possibility for solving the problem of radiation transfer without knowing the parameters of the scattering medium in advance.

Figures 2; references: 5 Russian.  
[497-6508]

# SELF-FOCUSING OF LASER RADIATION INDUCED BY NONEQUILIBRIUM OSCILLATING EXCITATION OF MOLECULES

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 55, No 6, Jun 85  
(manuscript received 21 Apr 84; in final form 13 Sep 84) pp 1172-1174

OSIPOV, A. I., PANCHENKO, V. Ya. and FILIPPOV, A. A., Moscow State University imeni M. V. Lomonosov

[Abstract] An estimate is presented of the self-focusing effect induced by nonequilibrium oscillating excitation of molecules in a laser beam. Propagation of laser radiation is accompanied by nonequilibrium oscillating excitation of molecules leading to an increase in polarizability and, consequently, index of refraction. Thus, in a laser beam channel a medium is formed with increased index of refraction, causing focusing. Equations derived in the article are used to estimate the self-focusing of laser radiation in  $\text{SF}_6$ . The calculated results are compared with experimental results, yielding good agreement. References 8: 4 Russian, 4 Western.  
[497-6508]

UDC 621.373.826:535.34

# METHOD FOR DETERMINING PARAMETERS OF ACTIVE MEDIUM OF ELECTRICAL DISCHARGE $\text{CO}_2$ LASERS FROM ABSORPTION AND RADIATION IN CENTERS OF $00^01-00^00$ and $10^01-00^00$ BANDS OF $\text{CO}_2$ MOLECULES

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 4, Apr 85  
(manuscript received 1 Dec 83) pp 553-559

BAKHIR, L. P. and TAMANOVICH, V. V.

[Abstract] This study extends earlier work by the author on determining the vibration temperatures of the upper and lower lasing levels of linear triatomic molecules from the Planck functions for the  $00^01-00^00$  and  $10^01-00^00$  vibration-rotation transitions. Methods are developed for finding the basic parameters of the active media employed in  $\text{CO}_2$  electric discharge lasers from experimental data, obtained with Svirel' instruments, needed for assessing the efficiency of existing pumping systems. Figures 2; references 7: 6 Russian, 1 Western.  
[432-6900]

POLARIZATION AND ENERGY CHARACTERISTICS OF CO<sub>2</sub> LASER RADIATION WITH MISALIGNED CAVITY MIRRORS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 4, Apr 85  
(manuscript received 30 Jan 84) pp 570-574

SNOPKO, V. N. and TSARYUK, O. V.

[Abstract] The changes in the polarization and energy characteristics of multimode emission from a CW CO<sub>2</sub> laser when one of the cavity mirrors is misaligned are investigated. The intensity of orthogonally polarized waves is found to change when the cavity is misaligned. This is explained by coupling between waves with different polarization and by competition of the anisotropy of the medium caused by nonlinear effects and anisotropy of the cavity caused by misalignment of one of the mirrors. Figures 3; references 9: 7 Russian, 2 Western.  
[432-6900]

UDC 621.378.325

## Q-MODULATION OF NEODYMIUM LASER UTILIZING PHENOMENON OF NONLINEAR TOTAL INTERNAL REFLECTION

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 4, Apr 85  
(manuscript received 16 Jan 84) pp 646-648

RUBINOV, A. N. and KORDA, I. M.

[Abstract] The phenomenon of nonlinear total internal reflection from the interface boundary between a dielectric and a phototropic dye solution is investigated for Q-modulating a neodymium laser. The laser cavity consists of two flat dielectric mirrors with reflection coefficients of 100% and 50% applied to tapered substrates. A 10x160 mm GLS-22 active element with ends inclined at an 85° angle to the axis of the cavity is employed. The Q-modulator consists of a cuvette with two reflections from the interface boundary per pass. Output energy of up to 2 J with pulse duration of approximately 20 nsec is obtained. Shutters based on nonlinear total internal reflection can be used to produce high-power single radiation pulses, as the Q-switching process occurs in a thin boundary layer, which significantly improves the spatial homogeneity of the radiation generated. Figures 1; references: 2 Russian.  
[432-6900]

THE NATURE OF ABSORPTION IN EMISSION REGION OF CO<sub>2</sub> LASER AND LASER  
DESTRUCTION OF KCl CRYSTALS DURING FIRST STAGE OF RADIATION COLORING

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 42, No 4, Apr 85  
(manuscript received 18 Jan 84) pp 648-650

GEKTIN, A. V., CHARKINA, T. A. and SHIRAN, N. V.

[Abstract] The nature of absorption in the 10.6  $\mu\text{m}$  region and of laser destruction of KCl crystals during the first stage of radiation coloring is established. Crystal impurities are the main factor that influence these characteristics. The relationship between the content of hydroxyl ions in the KCl crystals, and the change in their transmission in the CO<sub>2</sub> lasing region resulting from gamma radiation, are studied. The increase in crystal absorption and the drop in the optical destruction threshold are explained by the formation of defects caused by radiation. Figures 2; references 7: 4 Russian, 3 Western.  
[432-6900]

/9835

CHARACTERISTICS OF X-RADIATION EMITTED DURING FOCUSING OF LASER BEAMS ON  
SOLID TARGETS: RADIATION LOSSES IN MULTICHARGE PLASMA

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P. N. LEBEDEVA  
in Russian Preprint No 11, 1984

VINOGRADOV, A. V. and SHLYAPTSEV, V. N., Laser-Plasma Laboratory

[Abstract] Properties of x-radiation in the "x-ray lithographic" 8-12 Å region of the spectrum emitted by a homogeneous multicharge plasma are evaluated within the ranges of temperature and density characteristic of a laser plasma above solid targets. First, on the basis of numerical analysis and with approximation over the

$$\frac{1}{4} \leq \beta = I_z/T_e \leq 8 \text{ range } (I_z - \text{ionization}$$

potential of z-valent ion,  $T_e$  - electron temperature), analytical relations are established for atomic and ionization constants. Ionization and photo-recombination rates in a steady plasma as well as in a fast excited and recombining one are determined, taking into account the relationship between ionicity distribution of atoms and electron concentration. A steady plasma is one in a state of local ionization equilibrium, which in the extreme cases of very low density and very high density becomes the state of local corona equilibrium and the state of local thermodynamic equilibrium respectively. The rates of radiation processes are calculated next, assuming a plasma optically thin for its intrinsic radiation. The radiation losses in plasma are then calculated, considering the continuous spectrum formed by bremsstrahlung and recombinational radiation as well as the discrete line spectrum formed by radiative transitions between ion levels and radiation from dielectron satellites. These losses and the spectral distribution of radiation energy are determined separately for a steady plasma and a non-steady one. Figures 6; references 34: 18 Russian, 16 Western.  
[443-2415]



CHARACTERISTICS OF X-RADIATION EMITTED DURING FOCUSING OF LASER BEAMS ON  
SOLID TARGETS: LASER RADIATION TO X-RADIATION CONVERSION COEFFICIENTS

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P. N. LEBEDEVA  
in Russian Preprint No 117, 1984

VINOGRADOV, A. V. and SHLYAPTSEV, V. N., Laser-Plasma Laboratory

[Abstract] Conversion of laser radiation to x-radiation in a laser plasma above solid targets is examined, taking into consideration gas dynamic and atomic as well as radiation processes. The fundamental equations of the mathematical model describing a laser plasma includes only resonance and nonlinearity mechanisms of radiation absorption, assuming complete absorption at the critical electron concentration. It disregards effects of stimulated Mandelshtam-Brillouin and Raman scattering associated with generation of fast electrons. The model is limited to an optically thin plasma and a one-dimensional corona dispersal, corresponding to irradiation of plane targets in spherical or cylindrical configurations with "circle" or "line" focusing respectively. On this basis are calculated the radiation losses and subsequently the radiation conversion coefficient, both depending on the laser radiation flux density. Targets of heavy elements forming multicharge plasmas such as copper with the atomic number  $Z = 29$  are of technological interest, especially their x-radiation spectrum and the radiation conversion coefficient within the 1-1.5 keV energy range. Results based on "classical" and "non-Spitzer" electron components of thermal conductivity respectively are compared, deviations from the classical model being attributable to such possible causes as ion-acoustic turbulence, or electric and magnetic fields, or plasma density and temperature gradients. Figures 8; tables 2; references 25: 13 Russian, 12 Western.  
[443-2415]

ROLE OF SHOCKWAVE IN REFLECTION OF PLASMA FLAME FROM SOLID STATE OBSTACLE

Moscow O ROLI UDARNOY VOLNY PRI OTRAZHENII PLAZMENNOGO FAKELA OT TVERDOTELNOGO  
PREPYATSTVIYA in Russian 1983 pp 2-18

BOROVSKIY, A. V., Laboratory of Applied Hydrophysics, Physics Institute  
imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] Experiments are described in which plasma glow during the collision of an expanding laser flame with a solid state obstacle was investigated. In one of the studies, the plasma flowed about a wire located a certain distance from the surface of the flat target on which the laser radiation was focused. In the other, the laser flame was aimed obliquely at an obstacle located a certain distance from the focal point of the laser radiation. In both cases, there is an increase in the penetrating glow when the flame collides with the wall, which is associated with amplification of the recombination processes near the wall due to compression of the plasma

by the reflected shockwave, and perhaps by cooling of the plasma by the electron heat conductivity on the wall. In general, a reflected shockwave occurs when the plasma flux collides with an obstacle. If the density of the matter in the incident flow is small, the width of the sharp wavefront may be comparable with the characteristic distance of the problem, in which case the structure of the shock wave will look like an isoelectronothermal jump. If the density of the matter is higher, the reverse situation is possible, in which the width of the front of the shockwave is much smaller than the characteristic distance, in which case the gas dynamic parameters of the plasma at the shockwave front are related by the ordinary laws of preservation of mass, impulse, and energy. The reflected shockwave retards the incident flux, converting kinetic energy to compression energy and to internal energy, mainly of the ion component of the plasma. The plasma that is less than 1 cm from the obstacle is apparently cooled by the electron heat conductivity on the wall to temperatures of 10-15 eV. An interpretation is provided for the occurrence of a region of penetrating glow next to the wall in the oblique-incidence study. Figures 2; references: 13 Russian, [438-6900]

UDC: 621.039.61

GENERATION OF ELECTROMAGNETIC RADIATION BY BEAM OF ELECTRONS IN PLASMA WITH DEVELOPED ION-ACOUSTIC TURBULENCE

Moscow FIZIKA PLAZMY in Russian Vol 11, No 8, Aug 85  
(manuscript received 5 Oct 84) pp 952-956

BYCHENKOV, V. Yu. and CHOKPAROVA, G. A., Physics Institute  
imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] Generation of high frequency electromagnetic radiation is related to development of instability resulting from the interaction of a beam of fast low density electrons with ion-acoustic turbulence. The physical cause of this instability is related to induced wave scattering by beam particles. The instability in question may result in either nonthermal microwave radiation or amplification of a wave of finite amplitude propagating through the turbulent plasma. Figure 1; references 19: 9 Russian, 10 western. [589-6508]

## ACCELERATION OF ELECTRONS IN A PLASMA-BEAM DISCHARGE

Moscow FIZIKA PLAZMY in Russian Vol 11, No 5, May 85

(manuscript received 11 Mar 84; revised version 27 Jun 84) pp 622-625

KOCHMAREV, L. Yu., LYAKHOV, S. B., MAYOROV, A. D., MANAGADZE, G. G., CHMIL', A. I. and SHUSTIN, Ye. G., Institute of Radio Engineering and Electronics, USSR Academy of Sciences; Institute of Space Research, USSR Academy of Sciences

[Abstract] Preliminary results are presented from laboratory experiments studying the electron distribution function of electrons scattered from a plasma-beam discharge. Experiments were performed under conditions approximating the conditions of the 'Gruziya-60--Spurt' experiment involving injection of electron beams into space. The electron distribution function was studied by an analyzer which could be moved along the axis of the chamber from 75 to 210 cm from the injector. The results of the experiment confirm one possible explanation of the anomalously high probe potential observed in the field experiment. There is a 2-peak curve in the precharging chamber on the electron distribution function with its minimum at the beginning of the initial beam energy. As pressure or beam current increases and the plasma beam discharge develops, the electron distribution function expands in the direction of lower energies. Spontaneous variation of beam discharge parameters was observed through the duration of the injected current pulse. The forms of the distribution function differ significantly. During the second state it retains a bell shape at all scattering angles, whereas in the first stage it is expanded in the direction of lower energies and smoothed. Figures 3; references 12: 9 Russian, 3 Western.  
[496-6508]

UDC: 533.951.8

## MHD EDDIES IN A TOKAMAK

Moscow FIZIKA PLAZMY in Russian Vol 11, No 5, May 85

(manuscript received 29 Feb 84) pp 633-635

MIKHAYLOVSKIY, A. B., LAKHIN, V. P. and MARCHENKO, V. A., Institute of Atomic Energy imeni I. V. Kurchatov

[Abstract] The possibility is demonstrated of existence of eddies in a plasma held in a toroidal magnetic field. An axisymmetrical circular cross section tokamak with high aspect ratio is used as the example of a toroidal magnetic trap. The plasma is described by the equations of single-fluid magnetic hydrodynamics. The work is suggested as a starting point for development of a more general theory of eddies in plasmas held in toroidal geometry, since the analysis here presented can be extended to the case of more complex magnetic field geometry, and can consider drift, resistive and kinetic effects. References 4: 3 Russian, 1 Western.  
[496-6508]

## ELECTRON ENERGY BALANCE IN NON-INDEPENDENT GAS DISCHARGE

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 23, No 2, Mar-Apr 85  
(manuscript received 22 Mar 84) pp 235-239

SOPIN, P. I., Moscow Physical-Technical Institute

[Abstract] An approximate method is proposed for determining the parameters of the plasma of a non-independent discharge based on calculating the electron energy balance, assuming a weak difference in the type of electron energy distribution function in dependent and independent gas discharges in the low-energy region for a fixed value of the average plasma electron energy. The basic plasma chemical reactions involving charged particles in the plasma formed by an electron beam in nitrogen or a nitrogen-oxygen mixture at near-atmospheric pressures are investigated. The energy balance of the low-energy electrons of the plasma of a non-independent discharge is studied. It is found that the average energy depends quite strongly upon the rate of formation of secondary electrons for comparatively weak electrical field intensities. The proposed model can be used to estimate the parameters of the plasma of the nonindependent gas discharge initiated by an electron beam fairly simply. The findings demonstrate the influence of the electron beams, the electrical fields, and the characteristics of the medium on the electron energy balance. The results can be used in determining such plasma parameters as conductivity and charge composition. Figures 4; references 17:

14 Russian, 3 Western.

[420-6900]

## INFLUENCE OF RECHARGING PLASMA TARGET ON FORMATION OF BEAM OF FAST HYDROGEN ATOMS

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 11, No 12,  
26 Jun 85 (manuscript received 12 Feb 85) pp 720-725

D'YACHKOV, B. A., MESHKOV, V. Ye. and KAZANTSEV, G. V., Institute of Solid State Physics, USSR Academy of Sciences

[Abstract] An important question in the production of neutral hydrogen atoms by passage through a recharging plasma target is the influence of the target on the angular divergence of the beam. This work presents a description of measurements of the scattering angle formed when negative hydrogen ions with an energy of 180 KeV strike a cesium plasma target. The plasma target is found to have focusing properties for beams of negative ions with density up to  $10^7 \cdot \text{cm}^{-3}$ . Figures 2; references: 5 Russian.

[529-6508]

/9835



## SUPERCONDUCTIVITY

### WORK ON SUPERCONDUCTIVE EQUIPMENT FOR POWER STORAGE SYSTEMS

Moscow IZVESTIYA in Russian,

13 Sep 85 p 1

[Article by N. Golovkova]

[Excerpt] The world's first industrial units for storing magnetic energy are being developed at the "Gorizont" design and experimental bureau of the USSR Ministry of Power and Electrification. These units will permit radical improvement of the technical and economic performance of future power engineering equipment. A mock-up of a superconductive electric power storage station of the future is being shown in the "Electrification" pavilion at the USSR Exhibition of National Economic Achievements (VDNKH SSSR).

At Power and Heating Plant No 22, which supplies the Moscow suburb of Lyubertsy with heat and electric power, the "Gorizont" bureau has its own building, where we met with Candidate of Technical Sciences Yevgeniy Semenovitch Gol'denberg, head of the bureau's department of superconductive magnetic systems.

"We still have an hour left before an experiment," the scientist said. "That's enough time to talk a little about our electricity storehouses."

As long ago as the beginning of this century, the Dutch physicist Kamerlingh Onnes discovered that electrical resistance disappears in highly cooled conductors. If current is directed into a superconductive loop, it will be able to circulate perpetually, because there is just no way it can dissipate.

The distance from the concept to the mechanism was tremendous, but the time has now come to begin work on the creation of industrial superconductive 'rings' in which continuous electric currents will run.

"There are no theoretical barriers to creating superconductive storage devices, only psychological resistance to transferring to technology that is new in principle," said Ye. Gol'denberg. "Our group decided to take the shortest route to introduction. It first developed a laboratory model which stores one kilowatt-hour. Then came a unit that is a thousand times as large. A storage station with the unheard-of capacity of one million kilowatt-hours is the ultimate objective."

The first model, which was in a room, looks like a toy. Its cryostat, instruments and control panel could all be transported at once on a porter's



cart. When voltage is switched on, the model's superconductive winding is charged with current, which discharges itself in ballast resistors in a powerful burst.

The second model is now being built. Laboratory technicians are installing its cryostat, and its size is impressive. The casing for its cold zone is a steel cylinder whose dimensions are about those of a two-story elevator shaft in an apartment building. But even this size is not a record one; physicists have already built hundreds of superconductive magnets weighing thousands of tons.

One can gain an impression of the third unit by visiting the VDNKH SSSR exhibit. In its "Electrification pavilion, visitors see a mock-up of a superconductive power storage station. Imagine a stadium with a cold cable running through a tunnel underneath the stands surrounding the soccer field. This loop alternately 'absorbs' electric power and releases it in 500-megawatt portions into a power system, in cycles lasting two hours each.

FTD/SNAP/9835  
CSO: 1862/041

## TECHNICAL PHYSICS

### MULTIFRAME HIGH SPEED SYSTEM FOR INTERFEROMETRIC PHOTOGRAPHY OF PLASMA IN LASER THERMONUCLEAR FUSION EXPERIMENTS

Moscow MNOGOKADROVAYA VYSOKOSKOROSTNAYA SISTEMA DLYA INTERFEROMETRICHESKOGO FOTOGRAFIROVANIYA PLAZMY V EKSPERIMENTAKH PO LAZERNOMU TERMOYADERNOMU SINTEZU in Russian 1983 pp 1-28

VALUYEV, A. D., VASIN, B. L., MAY R. G., SMELKOV, A. I., SKLIZKOV, G. V. and FEDOTOV, S. I., Special Design Bureau, Laboratory of Laser Plasma, Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] A seven-frame system for interferometric photography of laser plasma is described. The camera provides high speed (up to  $2 \cdot 10^9$  frames per second) and high resolution (up to 100 lines per millimeter) recording of interference images, and is employed in laser thermonuclear fusion experiments on the Del'fin-1 system. The device incorporates an OLZ-7-40 optical delay line and an FKI-7-100 seven-frame camera. The design of the matching optics and the interferometer are described in detail. The use of the equipment in experiments on the heating and compression of special shell targets on the Del'fin-1 system is described. The successful operation of the system demonstrated the success of most of the circuit and design treatments, as well as the reliability of the equipment. New physical findings were obtained in the area of investigations of interaction between powerful radiation and matter. Figures 13; references 13: 8 Russian, 5 Western.  
[438-6900]

## SCIENCE FOR PRODUCTION

Kiev INSTITUT POLUPROVODNIKOV in Russian 1985 (signed to press 24 Jan 85) pp 138-143

[Abstract] A great deal of activity at the Institute of Semiconductors, UkSSR Academy of Sciences, is oriented toward incorporation of scientific achievements in the USSR national economy to a larger extent and at a faster pace. Research in major areas, such as optics and photoelectronics, semiconductor materials, optoelectronics, physics of surface and contact phenomena, accordingly, involves consideration of the national economy as a criterion for goal setting and problem solving. Photoelectric devices already developed by the Institute are high-quality radiation detectors, exposure meters, and irradiation dosimeters covering a wide range of the spectrum from x-ray to

infrared wavelengths. Optoelectronic devices already developed by the Institute include photopotentiometers, light amplifiers, and optical decoders, transmitters, converters, data storages, and a precision d.c. millivoltmeter (F-5090) with optoelectronic analog readout without moving mechanical parts. Devices already commercially produced are an optoelectronic potentiometer (PF-1), a high-capacity electroluminescent thin-film display screen, converters of various physical quantities (temperature, pressure, magnetic induction), gas analyzers, and a semiconductor-type pressure transducer (PDM-2) which detects induced anisotropy of electrical conductivity. An automatic instrument for measurement of static and dynamic magnetic fields has been developed on the basis of magnetoresistance effects in thin semiconductor films. A set of transducers including a low-cost semiconductor device which measures simultaneously the temperature (4.2-500 K) and the magnetic induction has been developed for use in the Tokomak-15 fusion reactor. One of the Institute's traditional activities is development of the physical principles and technical capabilities of solar cells, the latest technology already made available being that of silicon and  $A^{II}B^{VI}$  crystals. All developments are negotiated and coordinated for production with respective industrial enterprises and with other concerned Institutes of the UkSSR Academy of Sciences, as well as with appropriate special design and manufacturing engineering offices. All activities of the Institute are formalized by participation in all-Union, UkSSR, regional, and municipal scientific-technical programs as well as in programs at interindustrial, interdepartmental, and ministerial levels.

[586-2415]

UDC: 538.561

# SPECTRAL-ANGULAR CHARACTERISTICS OF RADIATION OF BEAM OF RELATIVISTIC CHARGED PARTICLES IN WIGGLER. II

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 55, No 6, Jun 85  
(manuscript received 21 Dec 83; in final form 10 Sep 84) pp 1090-1098

ALFEROV, D. F. and BASHMAKOV, Yu. A., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] A quantitative study is presented of the variation of radiation characteristics as a function of angular spread of particles in a beam. The spectral-angular characteristics of the radiation are studied as functions of the angle of divergence of the particles in the beam in the small fields mode in a wiggler. Expressions are derived in universal form for the spectral-angular distribution of polarization intensity components in the beam of relativistic charged particles. Results of numerical analysis of the properties of wiggler radiation of actual electron beams are compared to experimental data, showing good agreement. Figures 6; references 9:

7 Russian, 2 Western.

[497-6508]

HIGH CURRENT RELATIVISTIC ELECTRON BEAM IN MAGNETIC QUADRUPOLE-  
SOLENOID SYSTEM

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 55, No 6, Jun 85  
(manuscript received 18 May 84; in final form 10 Oct 84) pp 1179-1182

CHIKHACHEV, A. S., All-Union Electrotechnical Institute imeni V. I. Lenin,  
Moscow

[Abstract] A study is made of the behavior of a beam with compensated charge in a mixed system of external fields in the case when the equations of motion describing transverse oscillations of beam particles can be separated. It is assumed that the transverse cross section of the beam is an ellipse. The method described can also be used to study the behavior of a beam in an accelerating gap of a combined solenoid-quadrupole system. Rotation of the quadrupole system must be matched with the longitudinal magnetic field in either case. References: 3 Russian.

[497-6508]

/9835

## THERMODYNAMICS

### THERMODIFFUSION INSTABILITY OF GAS MIXTURES IN LASER RADIATION FIELDS

Moscow TERMODIFFUZIONNAYA NEUSTOYCHIVOST GAZOVYKH SMESEY V POLE LAZERNOGO IZLUCHENIYA in Russian 1983 pp 1-28

IRICHENKO, N. A. and MOROZOV, Yu. Yu., Laboratory of Applied Hydrophysics, Institute of General Physics, USSR Academy of Sciences

[Abstract] The problem of thermodiffusion instability of gas mixtures in a laser radiation field is examined as an example of the problem of systems that are far from a state of thermodynamic equilibrium, in which the non-linear interaction and transfer processes can result in the formation of dissipative structures--stationary inhomogeneous spatial distributions of the variables. Laser radiation incident on a thin cuvette containing a mixture of two gases such that the change in the temperature of the gas and the intensity of the radiation by depth can be disregarded is investigated. It is noted that complex inhomogeneous structures can develop due to other mechanisms as well, and that the development of such instabilities is strongly influenced by thermodiffusion, as well as instability of the laser beam itself as it propagates through the medium. Figures 8; references: 14 Russian.  
[438-6900]

### BISTABILITY IN LASER HEATING OF CHEMICALLY ACTIVE MEDIA

Moscow BISTABILNOST PRI LAZERNOY NAGREVE KHIMICHESKI AKTIVNYKH SRED in Russian 1983 pp 1-19

ALIMOV, D. T., YEDVABNIY, I. V., LUKYANCHUK, B. S. and KHABIBULLAYEV, P. K., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The phenomenon of thermochemical bistability occurring in a continuous chemical reactor in which a laser is fired into the chemically active medium is analyzed theoretically. Basic formulas describing thermochemical bistability are derived. The parameters of the hysteresis loop are determined using approximate analytical expressions that describe the variation in the dimensionless temperature along the loop. The critical point of the reactor, and the unsteady processes occurring in the reactor, are analyzed. The thermochemical bistability examined differs significantly



from the familiar bistabilities dealt with in the theory of exothermic chemical reactions, in which the energy source is the heat from chemical reactions in systems that are closed with respect to mass exchange. In the present case, the system is also closed with respect to mass exchange, but the energy source is laser radiation. Such reactors with bistable behavior can be used as a shutter or modulator in high-power CW lasers. The nonlinear diffusion equation used to analyze the system in question describes a very broad class of physical phenomena. Figures 5; references: 10 Russian. [438-6900]

UDC 539.3:534.1

#### IMPACT DEFORMATION OF METALS TAKING INTO ACCOUNT BULK MODULUS AND TEMPERATURE

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKhanika TVERDOGO TELA in Russian No 4, Jul-Aug 85 (manuscript received 23 Aug 84) pp 103-110

MAYBORODA, V. P. and KHOLIN, N. N., Moscow

[Abstract] Dynamic inelastic deformation of metals under impact is analyzed on the basis of a thermodynamic model which accounts for dependence on both the temperature and the bulk modulus of the material. The thermodynamic state of a metal is accordingly determined by the elastic-strain tensor, the absolute temperature, and the internal state describable by the corresponding equations of kinetics. Stipulating an extremal deformation process rather than any other possible process of inelastic deformation and assuming that all elasticity constants of a metal are independent of its inelastic properties, one arrives at an associated law of plastic flow which yields an inelastic-strain rate tensor separable into strains dependent on and strains independent of the time scale. This law also yields the corresponding dissipation function. For specificity a Mises-Schleicher kind of hardenable material is considered. Deformation of such a metal at high temperature and under high pressure is analyzed on the basis of the Navier-Stokes equations of flow for a compressible medium with axial symmetry and the Mie-Grüneisen equation of state. For a solution by the method of finite differences, the two-dimensional problem is reduced to a system of one-dimensional ones. Here inertia and viscosity terms of the momentum equations are assigned to the upper time layer and pressure terms are assigned to the lower time layer, which allows further splitting of this system of equations and reducing its solution to successive solutions of scalar algebraic equation systems with tridiagonal matrices. The boundary conditions are approximated according to the 3-point rule of second-order precision. The scheme is stabilized by means of special smoothing operators and regularization of high-frequency oscillations. This model and the method of numerical analysis have been applied to aluminum cylinders and heating of the latter by an electromagnetic pulse to 6000 K, with the radius of the "hot" spot assumed to be 4.5, 3.0, 1.5 cm respectively or by a thermal radiation pulse to 1000 K. The amplitude of primary deformation shock waves is found to

depend on the initial temperature but not on the size of the "hot" spot. The cumulative effect of secondary shock waves, after intervening relaxation, is found to increase with increasing size of the "hot" spot. The defectiveness integral as local criterion of fracture is evaluated for a cylindrical heating pulse, deformation under a pulse of this form being characterized by a low probability of chopping the target on the back side and a high probability of chopping it on the front side. Figures 4;

references: 7 Russian.

[40-2415]

/9835

QUANTUM THEORY OF RADIATION EFFECTS DURING STOCHASTIC PARTICLE ACCELERATION

Moscow KVANTOVAYA TEORIYA RADIATIONNYKH EFFEKTOV PRI STOKHASTICHESKOM USKORENII CHASTITS in Russian 1983 pp 1-60

TSYTOVICH, V. N., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] Radiation corrections for stochastic particle acceleration, i.e., effects associated with change in the electromagnetic mass of the accelerating particle, are investigated. A quantum theory of radiation effects is constructed that predicts the occurrence of step tail particles regardless of the type of random fields, their distributions by wave numbers (turbulence spectra), or the nature of correlations (strong or weak turbulence). The spectrum is obtained for nonrelativistic particles with sufficiently high energies that drops off rapidly as the particle energy increases. It is found that the qualitative regularities of fast particle generation coincide for isotropic particles for spin of zero and  $1/2$ . The generation of fast ultrarelativistic electrons and ions with spectrum of approximately  $1/\epsilon^3$ , which is close to the observed spectrum of cosmic rays, is thus a universal phenomenon that is independent of the spectrum and type of turbulence, as well as the particle spin. The generation of fast particles is of particular interest from the viewpoint of general physics because it occurs in a one-way fashion (if there are far more quasi-heat particles than there are fast particles). Figures 2; references 9: 7 Russian, 2 Western.  
[438-6900]

# SEARCH FOR EQUATION DESCRIBING CHANGE OF STATE OF SOLIDS

Baku DOKLADY AKADEMII NAUK AZERBAYDZHANSKOY SSR in Russian Vol 41, No 4, Jul-Aug 85 (manuscript received 29 Apr 84) pp 20-24

ALIYEV, O. Kh. M., Moscow Institute of Radio Engineering, Electronics and Automation

[Abstract] An equation is sought and obtained for describing the change of state of a solid body under an explosive impact load. Reasonably assuming that a shock wave is generated in the process and treating its front as an isolated surface at which the principal parameters of motion have discontinuities, the Rankine-Hugoniot relations are applied to the parameters of state on both sides of the wavefront. These relations are supplemented with the equation of adiabatic shock and the constraint  $F(p_2, J_2) = 0$  at the wavefront ( $p_2$ - hydrostatic pressure,  $J_2$ - second invariant of stress deviator). Spherical symmetry is assumed, since most available experimental data pertain to this case. It is also assumed that the explosive charge detonates instantaneously in a polytropically expanding gaseous medium, from which the propagating shock wave impinges on an only slightly deformable medium. The latter is either elastic or inelastic, with the boundary between media propagating respectively slower or faster than sound. Reduction of the number of equations by elimination of unknowns leads to a totally seventh-order system of integro-differential equations. The latter has been further reduced to a first-order one with a single argument, for formulation of the corresponding Cauchy problem and computer solution by a combination of two numerical methods: Runge-Kutta and Rombindt. Correlation with experimental data yields a power-law relation  $(J - J_c)^{n_1} + k_1(p - p_c) = 0$  describing the change of state of a solid body under a shock wave ( $J_c$ - critical value of  $J$ ,  $p_c$ - critical pressure,  $k_1 = (-J_c)^{n_1} p_c$ ) with the exponent  $n_1$  determined experimentally. The author thanks Kh. A. Rakhmatulin for discussion. Article was presented by Academician (AzSSR Academy of Sciences) N. A. Guliyev. Figures 1; references: 1 Russian. [17-2415]

EXPERIMENTAL CONFIRMATION OF STRONG POSTULATE OF IDEAL PLASTICITY UNDER  
QUASI-MONOTONIC LOADING

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE  
I TEKHNICHESKIYE NAUKI in Russian No 8, Aug 85 (manuscript received 9 Apr 84)  
pp 31-34

NOVIKOV, K. V., academician (UkSSR Academy of Sciences), LEVITAS, V. I. and  
ROZENBERG, O. A., Institute of Superhard Materials, UkSSR Academy of Sciences,  
Kiev

[Abstract] The strong postulate of ideal plasticity under quasi-monotonic loading has been confirmed experimentally for over 15 metals and alloys, following such a confirmation of the postulate of ideal plasticity under monotonic loading for 43 materials. In one experiment the microhardness of eight plastic materials (steels St.10, St.20, 30KhGSA, 40KhNMA, 38 KhMYuA; aluminum alloys D16T, AK6; special alloy U8) and three nonplastic alloys (bronzes V93, V95; magnesium-lithium alloy ML5pch) was measured on Vickers and Brinell scales with a PMT-3 tester, on the inside surface layers of hollow cylindrical specimens after their loading in tension to large strains. The data, analyzed on the basis of five possible behavior models (hardening and softening as well as ideal plasticity under constant load, postulated ideal plasticity under monotonically changing load, and strongly postulated ideal plasticity under quasi-monotonically changing load), reveal that for each of these materials there exists a hardness limit which does not depend on the deformation history and does not change during subsequent deformation. Under large strains, moreover, the materials deform as ideally plastic ones with the limiting ideal-plasticity surface  $F(\bar{\sigma}) = 0$  independent of  $\bar{\epsilon}^t(\tau)$  ( $\bar{\sigma}$ - tensor (vector) of real stresses invariant during rigid rotation of particle,  $\bar{\epsilon}$ - tensor (vector) of plastic strains,  $\bar{\epsilon}^t(\tau) = \bar{\epsilon}(t - \tau)$ - deformation history,  $t$ - Odquist parameter, time  $\tau > 0$ ) and that initially isotropic homogeneous materials deform as such. Figures 2; references: 8 Russian.  
[18-2415]



## BEHAVIOR OF POINT DEFECTS UNDER DYNAMIC PULSE LOAD

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 28, No 6, Jun 85 (manuscript received 3 Aug 82, after revision 30 Mar 84) pp 49-52

KRESTELEV, A. I. and BEKRENEV, A. N., Kuybyshev Polytechnic Institute  
imeni V. V. Kuybyshev

[Abstract] The behavior of interstitial atoms and vacancies in the field of a plane shock wave is analyzed, taking into account elasticity and drag under conditions where such a defect acquires more energy than necessary for activating its dislocation so that it will move within the crystal without thermal or other activation. The plane shock wave propagating through a crystal is treated as a soliton wave and motion of a point mass is assumed to be Newtonian. The relevant properties of a defect are described by two tensors. Motion of interstitial atoms without activation is found to be possible only under a high-pressure pulse load with a steep wavefront so that the potential barrier can be overcome. Vacancies, which in effect decrease the total crystal volume and whose motion activation energy is one order of magnitude higher than that of interstitial atoms, will under such conditions move in the opposite direction toward lower pressure. Figures 1; references 6: 5 Russian, 1 Western (in Russian translation).  
[581-2415]

## REFLECTION OF MICROWAVE OSCILLATION BY PLASMA LAYER CONTAINING CONTROLLED CONCENTRATION CHARGED CARRIER INHOMOGENEITY

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 19, No 6, Jun 85 (manuscript received 23 Apr 84) pp 1012-1016

ANTONOV, V. V., Scientific Research Institute for Mechanics and Physics,  
Saratov State University imeni N. G. Chernyshevskiy

[Abstract] The reflection of waves by a semiconductor layer containing an inhomogeneous concentration of charged carriers in which the degree of the inhomogeneity is controlled by external electrical and magnetic fields is investigated. The voltage-current characteristic of an electron indium antimonide semiconductor specimen is estimated quantitatively. The recombination rate and external constant magnetic field are found to move the pinch-effect threshold in the direction of stronger electrical fields. Expressions are derived for the coefficient of reflection of electromagnetic radiation by a semiconductor layer that completely covers the cross-section of a waveguide and is in the pinch-effect state. The effect of microwave oscillation reflection from a semiconductor plate containing a variable concentration inhomogeneity can be used to build limiters, microwave-band controllers, and wave transformation devices. Figures 4; references: 6 Russian.  
[525-6900]

## SHOCK WAVES IN LINEAR HEREDITARY MEDIA WITH SPATIAL DISPERSION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 283, No 1, Jul 85  
(manuscript received 29 Apr 84) pp 61-66

LOKSHIN, A. A. and ROK, V. E., All-Union Scientific Research Institute  
for Nuclear Geophysics and Geochemistry, Moscow

[Abstract] A one-dimensional model is proposed that describes the deformation process in a hereditary medium with allowance for the spatial coordinates, reflecting the connection between the deformation and the stress at a given point over time. It is demonstrated that longitudinal shock waves propagate in the model to within the velocity of instantaneous elastic waves  $\sqrt{E/\rho}$ , which confirms the assumption that effects from adjacent points cannot reach the point in question any faster than instantaneous-elastic (longitudinal) waves. The behavior of a semiinfinite rod is modeled as an example.

References: 2 Russian.

[527-6900]

UDC: 533.951.7

## LINEAR OSCILLATIONS OF A DENSE ION BEAM EXCITED BY AN ELECTRON BEAM

Moscow FIZIKA PLAZMY in Russian Vol 11, No 5, May 85  
(manuscript received 18 Oct 83; after corrections 21 May 84) pp 558-562

LOSHKOV, I. V., All-Union Electric Engineering Institute imeni V. I. Lenin

[Abstract] The possibility is demonstrated of development of instability upon resonance of natural axisymmetrical oscillations of a particle stream with slowly growing perturbations. An increase in the natural space charge oscillations with positive energy in a high density ion beam is an attribute of the instabilities studied. In an electron beam the wave has negative energy. Interactions of waves with different signs cause instability. The mean speed of movement of the ions does not increase in the linear stage; rather their oscillation energy increases in the field of the excited wave. For both tubular and solid electron beams instability upon development of natural oscillations of a thin high-current ion beam is weaker than for Cherenkov resonance of ions with excited waves. The growth of Langmuir oscillations of ions may lead to a significant increase in the distribution of longitudinal ion velocities and may therefore decrease the ion capture coefficient in the process of resonant acceleration. Figure 1; references 8: 6 Russian, 2 Western.

[496-6508]

# THE INFLUENCE OF SHOCK WAVES AND ERODING SHELL ON RADIATION PROPERTIES OF HIGH-CURRENT H-ATTACHED DISCHARGE

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 23, No 2, Mar-Apr 85 (manuscript received 16 Jan 84) pp 253-261

KALACHNIKOV, Ye. V., MIRONOV, I. S. and POGOVITSEV, P. N.

[Abstract] The extent and nature of the screening effect of an eroding gas envelope of H-attached discharge employed as a high-intensity radiation source in the visible and UV regions of the spectrum are investigated at different stages of development. An 8-channel diagnostic system used to investigate the radiation properties of the discharge and the gas envelope is described. The use of Tepler's method, laser sounding, photoelectric recording of the radiation at five wavelengths, photoelectric recording at two angles to the radiating layer, and high speed spectroscopy is described. The experiments indicate the occurrence of substantial screening of the radiation during the attenuation phase and afterglow phase of the discharge. The factors that distort the shape of the radiation pulse are identified. Ways of reducing the influence of shock waves and the erosion envelope are described. Figures 5; references: 11 Russian.  
[420-6900]

UDC 533.6.011

# PROFILE OF CYLINDRICAL SHOCKWAVE AND "PEAK" APPROXIMATIONS

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 49, No 2, Mar-Apr 85 (manuscript received 21 Jul 83) pp 244-250

LIKHACHEV, V. N.

[Abstract] The propagation of an axisymmetrical shockwave formed as the result of initial velocity discontinuity is investigated. The solution yields the universal characteristic profile of cylindrical shockwaves in the region of small Mach numbers. The non-exponential profile is obtained for cylindrical shockwaves. Comparison between cylindrical and spherical shockwaves indicates that the characteristic profile for cylindrical symmetry is not described by an exponential relationship, so that the peak approximation yields an incorrect wave profile. The pressure drop in the spherical wave occurs much more rapidly than in the cylindrical wave, and its width is far smaller than for cylindrical symmetry. Figures 2; references: 7 Russian.  
[428-6900]

## DETERMINATION OF DETONATION VELOCITY IN AEROSOLS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 282, No 1, May 85  
(manuscript received 14 Dec 83) pp 72-75

ASLANOV, S. K. and GIRIN, A. G., Odessa State University imeni I. I. Mechnikov

[Abstract] A closed investigation is made of a detonation wave in an aerosol that indicates a relationship between the detonation velocity and the droplet diameter. The investigation is based on a theoretically validated model of a droplet breaking up in a high velocity stream of gas. The analysis points out the existence of two modes in an aerosol with the required initial composition and dispersion, for which the Chapman-Jouget condition is satisfied and for which the self-sustaining property is ensured. Figures 3; references 8: 7 Russian, 1 Western.  
[415-6900]

## INFLUENCE OF SOLID STATE OBSTACLES ON RADIATION OF RECOMBINING LASER PLASMA

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P. N. LEBEDEVA  
(preprint) in Russian 1983 (signed to press 29 Jun 83)

BOYKO, V. A., BRYUNETKIN, B. A., BUNKIN, F. V., DERZHIYEV, V. I., DYAZHIN, V. M., MAYOROV, S. A., SKOBELEV, I. Yu., FAYENOV, A. Ya., FEDOSIMOV, A. I., SHYKHOV, K. A. and YAKOVLENKO, S. I., Laboratory of Applied Hydrophysics, Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The influence of solid state obstacles on the dynamics of expansion of laser plasma is investigated. Two groups of experiments are described, one employing high intensity of approximately  $10^{13}$  W/cm<sup>2</sup>, obtained by focusing a 15-20 J laser pulse in a spot approximately 0.1-0.4 mm in diameter, and a group with relatively low intensity of  $5 \times 10^{10}$  W/cm<sup>2</sup>, obtained by focusing a 10 J laser pulse to form a  $20 \times 0.2$  mm<sup>2</sup> line. The high intensity experiment employed a fluoroplastic-potassium target; the low intensity experiments employed beryllium. It was found that obstacles influence plasma glow by changing the hydrodynamic parameters, such as the electron density and temperature. A strong role is played by phenomena associated with the occurrence of shock waves. An increase in the glow intensity of the recombining plasma behind the shock wave reflected from the obstacle is reported. Solid-state obstacles are found to increase the glow intensity of the ion lines at those distances at which recombination pumping of the levels occurs. The results are explained qualitatively on the basis of the theory of the structure of a shock wave front in a plasma. Figures 8; references 19: 18 Russian, 1 Western.  
[448-6900]

/9835



UDC 62-50

SUFFICIENT CONDITIONS FOR FINITENESS OF PURSUIT TIME

Moscow PRIKLADNAYA MATEMATIKA I MEKhanika in Russian Vol 49, No 4, Jul-Aug 85 (manuscript received 16 Jul 84) pp 517-523

PSHENICHNYY, B. N. and SHISHKINA, N. B., Kiev

[Abstract] The pursuit problem defined as a differential game  $\dot{z} = f(t, z; u, v)$ ,  $z \in R^n$ ,  $u \in U$ ,  $v \in V$  ( $U \subset R^n$  and  $V \subset R^n$  are nonempty compacts,  $\dot{z}$  is the derivative of  $z$  with respect to time  $t$ ) in a Euclidean space  $R^n$  is solved by a method applicable to linear and nonlinear differential equations. The evader's strategy is any measurable function  $v(t)$ ,  $t \geq t^0$ , in compact  $V$ . The pursuer's strategy is any semicontinuous upper multivalent map of  $U(z)$  from  $R^n$  onto  $2^U$  (set of all subsets in compact  $U$ ). The method is based on the theory of convex analysis. Two theorems are proved, with the aid of six lemmas, which establish the possibility of concluding such a game and the sufficient conditions for concluding it in a finite time. Two examples demonstrate the effectiveness of this method in a problem of simple pursuit and in a problem of several pursuers. References: 9 Russian. [596-2415]

UDC 62-50

GAME OF OPTIMUM APPROACH INVOLVING TWO INERT OBJECTS AND ONE INERTIALESS

Moscow PRIKLADNAYA MATEMATIKA I MEKhanika in Russian Vol 49, No 4, Jul-Aug 85 (manuscript received 12 Jul 84) pp 536-547

LEVCHENKOV, A. Yu. and PASHKOV, A. G., Moscow

[Abstract] A pursuit game is considered which involves an inertialess object evading two controllable inert ones, with a fixed time as constraint and with the distance from evader to nearest pursuer at the end of the game as payoff functional. The problem is formulated in a moving system of coordinates tied to both pursuers so that the two axes are directed from the origin each to one of the pursuers with the latter remaining in symmetrical positions at any time and the relative positions of pursuers and evader thus completely defined. The problem is described by a quadratic equation for two three-dimensional regions of the phase space where one-to-one games take



place. Upon introduction of the program maximin and proof of its  $u, v$ -stability in the respective regions, the problem is solved for strategies of each player. The algorithm yields optimum controls for both pursuers which, by virtue of the symmetry, are analogous to that in a one-to-one game in a phase space. Figures 6; references 12: 10 Russian, 2 Western (1 in Russian translation). [596-2415]

UDC 62-50

#### EXAMPLE OF IRREGULAR DIFFERENTIAL GAME

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 49, No 4, Jul-Aug 85 (manuscript received 18 Oct 83) pp 682-684

TARASYEV, A. M., Sverdlovsk

[Abstract] The irregular differential two-person game  $\dot{x}_1 = x_2 + v$ ,  $\dot{x}_2 = u$ ,  $|u| \leq 1$ ,  $|v| \leq 1$  ( $x_1, x_2$  - state scalars,  $u, v$  - scalar controls) is considered for analysis of singular surfaces, with the payoff  $\sigma(x) = \max\{|x_1|, |x_2|\}$  and with the cost function  $c(t, x)$  constructable in the position space  $I \times \mathbb{R}^2$ . The simplicity or complexity of constructing it is examined, the determining factor being the number of smooth functions to be spliced for this purpose. The cost function is to satisfy the Isaacs-Bellman equation in partial Hamilton-Jacobi derivatives. It is found to coincide with the program maximin and to have a correspondingly simple analytical description on the time interval  $t \in [1, 2]$ . The author thanks A. I. Subbotin and V. N. Ushakov for formulating the problem and for steady interest. Figures 2; references 10: 9 Russian, 1 Western (in Russian translation). [596-2415]

UDC 518.517

#### CONSTRUCTION OF OPTIMUM STRATEGIES BY METHOD BASED ON SPECIAL MODEL OF OPPONENT

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 283, No 3, Jul 85 (manuscript received 28 May 84) pp 569-572

TARASOVA, V. P., Kalinin State University

[Abstract] Equivalent situations and associated strategies in different games are defined, with an empty set containing the smallest element and a closure containing the largest element. A certain set of associate strategies is regarded as a model for the opponent, whereupon a theorem pertaining to optimal strategy is proved on the basis of those definitions and with the aid of a simple lemma. The "opponent model" concept is refined to one containing a single strategy and constituting a basis for constructing

optimal strategies in games. The method of construction involves an 8-step procedure: 1) game-theoretical formulation of problem; 2) breakup of problem into two stages; 3) solution of problem in final second stage; 4) refinement of problem in initial first stage; 5) constructing proposed special model of opponent as strategy; 6) constructing optimum counter-strategy; 7) complementing definition of counter-strategy to strategy in the game; 8) applying the fundamental theorem and special opponent model. The procedure is demonstrated by minimization of the path length containing an arbitrary function extremum. The feasibility of devising optimum strategy by this method is formalized by a theorem, with a corollary pertaining to "natural" strategy, which is also proved with the aid of a simple lemma. Article was presented by Academician A. N. Tikhonov on 9 April 1984. References 6: 5 Russian, 1 Western (in Russian translation). [571-2415]

UDC 517.97

#### HIERARCHICAL PROGRAM CONTROLS IN LINEAR PROBLEM WITH FIXED ENDS

Alma-Ata IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR SERIYA FIZIKO-MATEMATICHESKAYA in Russian No 3, May-Jun 85 (manuscript received 8 Aug 83) pp 67-71

MIKH TAROV, M., Karanganda State University

[Abstract] A linear hierarchical game whose dynamics are described by a system of differential equations is examined in which the objective of each of the players at the top and bottom layers of the hierarchy is to translate the initial system of differential equations from an assigned initial state to an assigned end state by selecting the appropriate controls, and to minimize the quadratic functionals that estimate the quality of the control process. The functional minimized by the player at the bottom level is quadratic with respect to the control inputs, while the functional minimized by the player at the top level is quadratic with respect to the control inputs and the phase vector of the controlled system. A numerical example is presented and solved. References 15: 13 Russian, 2 Western. [522-6900]

/9835

COMPUTER SIMULATION OF PROCESSES IN SOLID-STATE LASER RADIATORS AND  
AMPLIFIERS WITH GLOW-TUBE PUMPING: ELECTRIC-DISCHARGE PUMPING SOURCES.  
THERMOPHYSICAL PROCESSES IN ENVELOPE AND ELECTRODES OF PULSE PUMPS

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P. N. LEBEDEVA  
in Russian Preprint No 189, 1984 KVANTOVAYA ELEKTRONIKA

GRADOV, V. M., ZHILTSOV, V. I., SKLIZKOV, G. V., TERYTYEV, Yu. I.,  
FEDOTOV, S. I. and SHCHERBAKOV, A. A.

[Abstract] Thermophysical processes in pulse pumps for solid-state lasers are analyzed on the basis of the results of computer simulation according to a theoretical model which includes mechanical and thermal stresses in the pump components. The thick-walled pump envelope is assumed to be in a plane state of stress and strain under an axisymmetric load consisting of internal pressure and heat. The corresponding system of equations covers pressure and temperature transients as well as the steady-state mechanical and thermal stresses. The dependence of maximum energy stored on the pulse duration is determined, taking into account residual stresses, whereupon an approximate theory of toughness is constructed and the dependence of this toughness on the relevant pump parameters is established. On this basis follows a simulation of processes which include deflection of the pump envelope, diffusion of the preionizing additive through the parelectrode regions, and thermal erosion of the electrodes. The mathematical model emphasizes cathodic processes at the cathode surface and in the boundary layer, the latter being subdivided into the space-charge region adjacent to the surface and the ionization region above it. The corresponding system of equations is solvable by the Runge-Kutta method. Although generally pulse pumps operate in the "cold" mode, at pulse repetition rates above 20 Hz thermal emission becomes the dominant mechanism so that relations for a thermoelectron cathode can be used as an approximation. The error of this approximation and other errors of the model are estimated on the basis of available data on various existing flash tubes (IFP-1200-8000-20000, INSh-6/250), which establishes the limitations on the model and its ranges of validity. Separate consideration is given to mechanical wear of the pump envelope and electrodes, for which a model of physico-chemical structure and processes has also been constructed and computer-programmed. Still unsolved problems are prediction of the pump life, accounting for nonideality of plasmas under high pressure in active media with strong absorption and low energy efficiency but desirable selectivity, simulation of nonequilibrium and transient discharge

with nonthermal plasma in atomic or molecular mixtures, and synthesis of pulse pumps with computer-aided design software. Figures 11; tables 1; references 69: 66 Russian, 3 Western.  
[443-2415]

COMPUTER SIMULATION OF PROCESSES IN SOLID-STATE LASER RADIATORS AND  
AMPLIFIERS WITH PHOTOTUBE PUMPING: ELECTRIC-DISCHARGE PUMPING SOURCES.  
ARC DISCHARGES

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P. N. LEBEDEVA  
in Russian Preprint No 190, 1984 KVANTOVAYA ELEKTRONIKA

GRADOV, V. M., MAK, A. A., KROMSKIY, G. I., SKLIZKOV, G. V., FEDOTOV, S. I.  
and SHCHERBAKOV, A. A.

[Abstract] Problems of modeling and computer simulation are analyzed in reference to the design of solid-state laser devices with glow-tube pumping. Electric pulse and arc discharges are considered specifically, a model being constructed for a cylindrically symmetric column in the diffusion approximation, with the corresponding system of differential equations put in a form for most efficient and accurate simulation of the processes. For most economical use of the computer, the radiation spectrum is optimally subdivided into intervals. It is furthermore necessary to validate the assumption of a plasma in the state of local thermodynamic equilibrium by first accounting for and then discounting the various factors which disturb that equilibrium, namely emission of radiation and temperature gradients as well as diffusion of charged particles toward the walls. In the case of arc discharge, a theory and a model are constructed for determining the electro-physical characteristics and the radiation characteristics of such discharge in inert gases and in vapors of alkali metals. Especially important from the standpoint of design and performance analysis are limiting and maximum attainable effects, and, the radiation spectrum. The system of differential and vector equations describing the discharge processes is based on valid experimentally verifiable approximations such as thermal equilibrium of the plasma and radiative energy transfer in the first-order approximation of spherical harmonics. Figures 12; tables 2; references 78: 58 Russian, 20 Western.  
[443-2415]



COMPUTER SIMULATION OF PROCESSES IN SOLID-STATE LASER RADIATORS AND  
AMPLIFIERS WITH PHOTOTUBE PUMPING: ELECTRIC-DISCHARGE PUMPING SOURCES.  
PULSE DISCHARGES

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P. N. LEBEDEVA  
in Russian Preprint No 191, 1984 KVANTOVAYA ELEKTRONIKA

GRADOV, V. M., KONSTANTINOV, B. A., MAK, A. A., SLIZKOV, G. V.,  
TERENTYEV, Yu. I., FEDOTOV, S. I. and SHCHERBAKOV, A. A.

[Abstract] Processes in electric-discharge pumping sources are analyzed on the basis of the results of computer simulation according to a theoretical model for a cylindrically symmetric discharge with a plasma in the state of thermodynamic equilibrium, assuming uniform plasma pressure and electric field distributions over the length and the cross-section of the discharge gap. The corresponding system of equations is constrained by appropriate boundary conditions and supplemented with equations of evaporation and condensation particularly applicable to quartz as the phototube material. Transient processes accompanying pulse discharges are evaluated, first disregarding and then including evaporation of the tube envelope. The quasi-steady stage of pulse discharges is of special interest, its electro-physical and spectral characteristics as well as attendant energy losses being evaluated with the aid of available experimental data on several existing flash tubes (IFP-800-1200-8000, INSh6/250, ISP-2500). The model is found to be adequate for performance analysis and design of power pulse and high-efficiency discharge tubes. Preliminary calculations indicate that interference coatings can be easily made highly effective when the plasma is optically dense and its any undesirable additional heating is avoidable. Figures 16; tables 4; references 62: 54 Russian, 8 Western.  
[443-2415]

UDC 517.949.8

NUMERICAL ALGORITHM FOR APPROXIMATING FUNCTIONS OF MANY VARIABLES WITH  
COMPLETE POLYNOMIALS AND ITS USE FOR ALGEBRIZING DIFFERENTIAL EQUATIONS OF  
MATHEMATICAL PHYSICS

Kiev MATEMATICHESKIYE METODY I FIZIKO-MEKHANICHESKIYE POLYA in Russian  
No 22, 1985 (manuscript received 9 Feb 83) pp 20-25

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Mathematics, UkSSR Academy of Sciences, L'vov

[Abstract] A general algorithm is constructed for calculating the numerical coefficients of a complete polynomial which approximates a function of several variables, in the process of converting a differential equation into a difference equation in problems of mathematical physics. This algorithm applies to complete polynomials of arbitrary degree and to difference schemes with arbitrary distribution of nodes. Its gist is first demonstrated on a simple case, namely approximating a function of a two-dimensional argument



$U = U[x, y]$  with a second-degree polynomial, and then extended to an arbitrary number of measurable variables and a polynomial of arbitrary degree. The problem is analyzed and solved in a Cartesian system of coordinates with appropriate rotation of the axes, considering that approximation with a complete polynomial is invariant with respect to orthogonal transformations of the coordinates (which is not so in the case of approximation with an incomplete polynomial). The error of such an approximation needs to be estimated, which can be done by assuming that in the Taylor series expansion all terms of more than one order higher than the order of the approximation are negligible. Typical examples illustrating the application of this algorithm are approximation of the differential equation  $\partial H_y / \partial x - \partial H_x / \partial y = J$  with a third-degree polynomial for conversion into the difference equation

$$\frac{1}{6}(H_{y2} - 3H_{y3} + 3H_{y4} - H_{y5} + 3H_{y6} - 3H_{y10}) + \frac{1}{6}(H_{x2} - 3H_{x3} + 3H_{x7} - H_{x8} + 3H_{x9} - 3H_{x10}) = J_1$$

and approximation of the differential equation

$$\partial^2 \phi / \partial x^2 + \partial^2 \phi / \partial y^2 = 0 \text{ with a third-degree polynomial for conversion into the difference equation } \frac{1}{6}(-6\phi_1 + 3\phi_6 + 3\phi_{10}) - (6\phi_1 + 3\phi_3 - 3\phi_7) = 0$$

equivalent

to the well known equation  $4\phi_1 - \phi_3 - \phi_6 + \phi_7 + \phi_{10} = 0$ . References:

1. Russian.

[25-2415]

UDC 519.854.62

#### ACCELERATION OF GOMORY'S ALL-INTEGER ALGORITHM

Tallinn IZVESTIYA AKADEMII NAUK ESTONSKOY SSR: FIZIKA - MATEMATIKA in Russian Vol 34, No 1, Jan-Mar 85 (manuscript received 13 Jan 84) pp 11-19

KIVISTIK, L., Tartu State University

[Abstract] Use of Gomory's all-integer algorithm is considered for solving a problem of linear programming, namely for maximizing the function

$$x_0 = a_{00} + \sum_{j \in J} a_{0j} (-x_j) \text{ under the constraint } x_1 = a_{10} + \sum_{j \in J} a_{1j} (-x_j) \geq 0 \text{ (} i \in I \text{)}$$

with  $x_j = -1(-x_j) \geq 0$  ( $j \in J$ ) an integer ( $j = 0, 1, \dots, N$ ) ( $I$ - set of basis variables,  $J$ - set of nonbasis variables,  $I \cup J = \{1, 2, \dots, N\}$ ) and all coefficients are integers. While solution by truncation methods and specifically according to Gomory's algorithm involves only a few iterations for some problems, it involves a vast number of iterations for others. This inconsistency is attributable to irregularity of these methods. The possibility of accelerating Gomory's all-integer algorithm is examined here, replacement of the generating constraints with the constraint

$$\sum_{i \in I} a_{i1} y_1 + \sum_{j \in J} \left( \sum_{i \in I} a_{ij} y_i \right) (-x_j) \geq 0 \text{ with } y_1 \geq 0 \text{ being one such possibility.}$$

The sought truncation is found by simplex iteration with the lexicographically maximum decrement of the  $j$ -th column in the 1-normal simplex table at each iteration. For selection of the coefficients of  $y_1$  which will yield optimum or acceptable solutions to such a problem, there are constructed five auxiliary problems which have four properties rigorously provable and concerning the solvability of the main problem. On the basis of these properties a variant of Gomory's basic all-integer algorithm is then constructed. The acceleration is found to be appreciable, in some cases confirming the expediency of this variant immediately. This has been demonstrated on a program for solving 100 problems solvable according to both basic and accelerated variants of Gomory's all-integer algorithm of an Apple II<sup>+</sup> microcomputer. The number of iterations was reduced to below 40 and the computer time was shortened correspondingly, even when up to 4000 iterations and up to 1952 s of computer time were required with the basic algorithm, revealing this accelerated algorithm to be a regular one. Acceleration can be made to occur on the first one or the first  $n$  iterations only, but this will not result in a regular algorithm. Tables 3; references: 5 Russian. [446-2415]

UDC: 621.039.548

#### MATHEMATICAL MODEL FOR DESCRIBING STRESSES IN MINIATURE FUEL CELLS

Moscow ATOMNAYA ENERGIYA in Russian Vol 58, No 3, Mar 85  
(manuscript received 19 Dec 83) pp 189-190

YEREMEYEV, V. S., IVANOVA, Ye. A., MIKHAYLOV, V. N., PUTILOVA, A. P.  
and CHERNIKOV, A. S.

[Abstract] A mathematical model of the stress-strain state of miniature fuel cells with an arbitrary number of layers is described that requires relatively little machine time. The method takes into account the complex effect of temperature and radiation loads, with no restriction on the number of layers that can be investigated. Allowance is made for change in the physical and mechanical properties of the materials as irradiation occurs. References 5: 3 Russian, 2 Western. [378-6900]

## EFFECTIVE ALGORITHM FOR MINIMIZING GENERALIZED TRAFTS FUNCTIONALS OF LINEAR THEORY OF ELASTICITY

Moscow PRIKLADNAYA MATEMATIKA I MEKhanika in Russian Vol 49, No 2, Mar-Apr 85  
(manuscript received 22 Mar 84) pp 292-298

TERESHCHENKO, V. Ya.

[Abstract] The problem of minimizing generalized Trafts functionals of the three-dimensional theory of elasticity is reduced to a minimax problem for the Lagrangian. The Lagrangian is proved to have a saddle point. An algorithm is proposed for finding the saddle point on coordinate functions that are subject to no constraint in the domain and at the boundary. The proposed approximate algorithms for finding the saddle point is validated, and the convergence of the approximate solution is investigated. References:

6 Russian.

[428-6900]

/9835

OPTIMUM CONTROL OF FUNCTIONAL AVERAGED ALONG TRAJECTORY

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 49, No 4, Jul-Aug 85  
(manuscript received 17 Jul 84) pp 524-535

PANASYUK, A. I. and PANASYUK, V. I., Minsk

[Abstract] The set of infinite optimum trajectories is defined first, whereupon solution of the problem of optimum control with a functional averaged along a trajectory and convergence to the limit along sequences of trajectories are used for establishing the set of long optimum trajectories and the set of main trajectories. Pertinent existence and uniqueness theorems are proved, the sets being tested for approximability, closure, and minimality. Averaging a functional along the optimum trajectory is considered next, taking into account standard large variation of trajectory. Problems of periodic optimization and of almost periodic optimization are then treated as special cases of optimum-on-the-average control. The problem of almost periodic optimization is solved for the class of linear systems with a quadratic functional, which narrows the set of admissible pairs and reduces the problem to one of nonlinear programming. This problem is one of transfer of power to a load through a network with power limitation at each input. The mathematical apparatus of optimum control on the basis of functional averaging is validated by eleven theorems, which are rigorously proved here. References 15: 12 Russian, 1 East German, 2 Western (both in Russian translation).  
[596-2415]

## PRINCIPLES OF CONTROLLING INFINITE-DIMENSIONAL DYNAMIC OBJECTS UNDER SLIDING CONDITIONS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 283, No 5, Aug 85  
(manuscript received 12 Jul 84) pp 1116-1119

ORLOV, Yu. V. and UTKIN, V. I., Institute of Control Problems, Moscow

[Abstract] Controlling dynamic objects describable by differential equations in a Banach space is considered, assuming that the control is a discontinuous function of the state vector and of the external actions. The mathematical apparatus constructed for this purpose can handle sliding conditions in an infinite-dimensional system just as well as in finite-dimensional ones. Equations of sliding with limited operators on the right-hand side, specifically a continuously reciprocal operator  $G_b$  ( $G = dS/dx$  - Fresch derivative), are derived for dynamic objects describable by an equation nonlinear with respect to the state and linear with respect to the control  $\dot{x} = f(x,t) + b(x,t)u(x,t)$ ,  $t \in [0,T]$ ,  $x(0) = 0$  ( $x(t)$  - abstract function in Banach space  $B$ ;  $u(x,t), f(x,t), b(x,t)$  - operator functions in Banach spaces  $B_2, B_1, (B_2, B_1)$  respectively). This is done by the method of equivalent control,  $u_{\text{equ}} = -(G_b)^{-1}Gf$  being found from  $S = G\dot{x} = Gf + Gbu = 0$  and inserted into the equation of dynamic objects, on the basis of a theorem validating the solution. Equations of sliding with an unlimited operator on the right-hand side, in the class of linear systems, are derived on the basis of another validating theorem. While the right-hand side of the equation of dynamic objects need not necessarily satisfy the Lipschitz condition in the case of only limited operators, the validating theorem for the case of an unlimited operator extends also to nonsteady operators on the right-hand side if operator  $f(x,t)$  is an additive one and satisfies the Lipschitz condition in  $(x,t)$ . Article was presented by Academician V. A. Trapeznikov on 29 April 1984. References 6: 5 Russian, 1 Western (in Russian translation). [583-2415]



## SYNTHESIS OF PARABOLIC SYSTEM POSITION CONTROL AND STOCHASTIC MAXIMIN

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 235, No 3, Jul 85  
(manuscript received 20 Jun 84) pp 553-559

SERKOV, D. A., Institute of Mathematics and Mechanics, Ural Science Center,  
USSR Academy of Sciences, Sverdlovsk

[Abstract] The problem of optimum position control is considered for a parabolic system, assuming that both control and interference are lumped in a finite number of internal points. The problem is formulated as a differential two-person game in a conflictingly controllable moving system. The problem is solved by the method of a stochastic maximum program. The optimal strategy with guaranteed result for the first player is devised on the basis of four theorems and a lemma, the first two theorems pertaining to the payoff and the saddle point respectively. The authors thank A. V. Kryazhimskiy and Yu. S. Osipov for fruitful discussions and helpful suggestions. Article was presented by Academician N. N. Krasovskiy on 5 May 1984. References 13: 8 Russian, 5 Western (3 in Russian translation).  
[571-2415]

UDC 62-50

## DETERMINATE STRATEGY AND STOCHASTIC PROGRAMS

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 49, No 2,  
Mar-Apr 85 (manuscript received 3 Oct 84) pp 179-190

KRASOVSKIY, N. N.

[Abstract] A control problem that minimizes a guaranteed result is solved by stochastic program synthesis. The object is described by the limited differential equation

$$\dot{x} = A(t)x + B(t)u + C(t)v, \quad t_0 \leq t \leq J,$$

where  $x$ ,  $u$ ,  $v$  are column vectors, and the matrix-functions  $A(t)$ ,  $B(t)$ , and  $C(t)$  are continuous. The control  $u$  and interference  $v$  are bound by the constraints  $u \in P$ ,  $v \in Q$ , where  $P$  and  $Q$  are compacts. The performance index is made up of the norm of the phase vector at the end of the process and of the integrals of control realizations and the dynamic interference. The information element at time  $t$  is made up of the signal reflecting the history of the real motion, including error, as well as the history of control that has been generated up to the moment  $t$ . The information error, dynamic error, and control are bound by geometric constraints. References: 10 Russian.  
[428-6900]

#### A METHOD FOR INVESTIGATING CONTINUOUS MARKOV SYSTEMS

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR. SERIYA TEKHNICHESKIKH NAUK in Russian Vol 38, No 2, Mar-Apr 85 (manuscript received 5 Feb 84) pp 23-31

BRUTYAN, V. K.

[Abstract] A general method is presented by which a unique differential matrix Riccati equation with its auxiliary equations is connected with a differential canonical equation of the form presented in the text. A system of differential equations is proposed for unknown  $v_{ij}$ ,  $i, j=1, 2$ , which remains symmetrical, permits integration in the presence of singularity, and is numerically stable. The system of equations derived is used to investigate problems of synthesizing a linear control and to construct an estimate of the state vector of continuous Markov systems with incomplete observations and observations distorted by noise. The method can be used to solve practical problems involved in the linear synthesis of Markov systems containing boundary conditions, perturbations, and point sensors of observations that are incomplete or disturbed by noise, and are described with partial derivatives. References: 6 Russian.  
[482-6900]

#### ANALYSIS OF STEADY-STATE ERRORS IN CONTROL SYSTEMS WITH ZONES OF INSENSITIVITY

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR. SERIYA TEKHNICHESKIKH NAUK in Russian Vol 38, No 2, Mar-Apr 85 (manuscript received 8 Jul 84) pp 32-37

KYUREGYAN, S. G. and AKOPYAN, R. A.

[Abstract] Steady-state errors are investigated in multidimensional automatic control systems in which the elements contain insensitive zones. The connection between the steady-state errors and parameters of the system is identified. The treatment of cases in which the transfer matrices of the system contain integrating sections are discussed. The findings make it possible to identify steady-state errors in measurement systems and automatic control systems and to correct them parametrically. Figures 3; references: 3 Russian.  
[482-6900]

## CONTROL OF MANIPULATOR IN SINGULAR POSITIONS

Moscow IZVESTIYA AKADEMIY NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian  
No 4, Jul-Aug 85 (manuscript received 3 Dec 84) pp 61-65

GLAZUNOV, V. A., Moscow

[Abstract] A manipulator is considered whose kinematic chain, an open one consisting of six rotationally paired links, can assume singular positions where the translation vectors of the six axes cease to be independent of one another. The last link holds a tong which can assume any position in space within the range defined by the six axes of the chain and whose initial displacement can generally be infinitesimal, as in bioengineering systems with velocity-vector control. This is not possible when the translation vectors of those six axes become dependent on one another. The problem then is to dislodge the tong from such a position by means of a kinematic screw, one of the five in this system. Such a control of the manipulator involves two operations, first detecting a singular position and then selecting the initial kinematic screw which most closely approximates the required one, both operations to be performed automatically. The algorithm of the first operation is constructed on the basis of the total elementary displacement, angular displacement of the tong plus linear displacement of its center point with the Clifford conversion factor, as the sum of the elementary angular displacements of all the other links. The resulting system of equations is formulated in Plücker coordinates, known for given generalized coordinates and tied to the manipulator frame. The algorithm of the first operation includes calculation of a sixth-order determinant, with the manipulator regarded being in a singular position when the absolute value of that determinant is smaller than some stipulated small  $\epsilon$ . The algorithm of the second operation provides for determining which of the five hinges and their axes has been involved and need correction, before the kinematic screw most closely approximating the required one is found. In the simplest case the control problem is solved on the basis of a local criterion, on testing a manipulator position for one particular singularity. In automatic contour control, however, the criterion is generally a global one covering the entire set of possible singular positions. As an illustrative example of a manipulator whose singular positions are controllable by this method of kinematic screws is one similar to the "Universal-15" automatic manipulator, in a position where axes 2 and 6 coincide with link pairs 2-3, 3-4 antiparallel and link pairs 4-5, 5-6 antiparallel. The author thanks F. M. Dimentberg for discussion and Ye. I. Vorobyev for helpful suggestions. Figures 3; references 5: 3 Russian, 2 Western.

[40-2415]

## CONTROL WITH DETERMINISTIC NOISE FOR A NONLINEAR SYSTEM

Sverdlovsk UPRAVLENIYE DINAMICHESKOY SISTEMOY in Russian 1985 pp 131-148

[Abstract] A study is made of an object, the motion of which is described by a vector nonlinear differential equation. The problem studied is that of selecting a control such that the system is carried from its initial state to an assigned end state. The problem is much more difficult than the analogous problem for a linear system because the solution of the initial system cannot be written in a convenient equation such as the Cauchy formula which can be used for a linear system. The methods used to describe the problem are correction based on the finite boundary condition and correction based on a parameter. The method of correction based on a parameter is superior to correction based on the finite boundary condition in many cases, its solution being near optimal. However, sometimes it is most convenient to combine the two methods.

[045-6508]

## CONTROL WITH RANDOM NOISE

Sverdlovsk UPRAVLENIYE DINAMICHESKOY SISTEMOY in Russian 1985 pp 148-181

[Abstract] Previous sections of this same work analyzed problems of control of dynamic systems assuming that the noise acting on the object is a predetermined fixed function of time. This chapter studies the case when the noise is a random function of time. One of the simplest systems for formation of this noise is utilized and for definition an object is analyzed, the motion of which is described by a simple differential equation. The optimal control program is determined.

[045-6508]

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UDC 621.394.5

MATHEMATICAL MODELS OF SYNCHRONOUS DATA TRANSMISSION AND DISTRIBUTION SYSTEMS

Baku DOKLADY AKADEMII NAUK AZERBAYDZANSKOY SSR in Russian Vol 41, No 4, Jul-Aug 85 (manuscript received 5 Dec 83) pp 3-6

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[Abstract] A mathematical model is constructed for analysis of synchronous discrete-data transmission and distribution systems in local communication networks with distributed control of random multiple access. Accesses in such a stochastic system are assumed to occur in a random number of intervals whose distribution is that of the corresponding generating function for a given interval between accesses. The distributions of queuing time and dwell time are determined on the basis of the "first come, first serve" principle. Two algorithms of access control are considered for a single-channel ring or two-way network: either transmission of control signals to each station from the preceding one with use of a corrective code for error monitoring or decentralized transmission of control signals continuously until confirmation. Article was presented by Academician (AzSSR Academy of Sciences) F. G. Maksudov. References: 3 Russian.  
[17-2415]

UDC 519.21

CONVERGENCE TO DIFFUSION PROCESSES OF SOME MULTIDIMENSIONAL CHARACTERISTICS OF FINITE MARKOV CHAINS IN SERIAL SCHEME

Kiev TEORIYA SLUCHAYNYKH PROTSESSOV in Russian No 13, 1985  
(manuscript received 22 Sep 83) pp 3-10

ANISIMOV, V. V. and LUKASHUK, L. I., Kiev State University  
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[Abstract] This study investigates the asymptotic behavior of multidimensional processes consisting of the number of arrivals in the states and the



total time spent in the states of uniform finite Markov chains in discrete as well as continuous time. The limiting case is examined in which the chains correspond to several essential classes and non-essential states, and the investigative processes converge, with the appropriate normalization, to multi-dimensional diffusion processes. Three theorems are states and proved. References: 12 Russian.  
[431-6900]

UDC 519.21

#### ONE CONVERGENCE OF THE MOMENTS OF THE SUMS OF QUANTITIES CONNECTED IN MARKOV CHAIN WITH TWO STATES

Kiev TEORIYA SLUCHAYNYKH PROTSESOV in Russian No 13, 1985  
(manuscript received 8 Sep 82, pp 56-60)

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[Abstract] A Markov chain is examined that consists of a sequence of series of magnitudes  $x_{n1}, \dots, x_{nk}$ , each of which can assume either a value of 0 or 1. It is assumed that  $k=k(n)$  is a monotonically increasing sequence of positive integers that approaches infinity. The conditions for the convergence of the moments of the sum  $S_{nk}=x_{n1}+\dots+x_{nk}$  to the corresponding moments of the probability distribution function presented in the text is investigated. A theorem presenting the conditions under which the limiting theorem of the moments of the distribution  $S(x)$  is applicable to the sum  $S_{nk}$  is stated and proved. References: 2 Russian.  
[431-6900]

UDC 519.21

#### LOCAL ASYMPTOTIC INFINITE DIVISIBILITY OF FAMILIES OF MARKOV PROCESSES

Kiev TEORIYA SLUCHAYNYKH PROTSESOV in Russian No 13, 1985  
(manuscript received 15 Sep 82) pp 80-90

TARASKIN, A. F., Kuybyshev Aviation Institute imeni S. P. Korolev

[Abstract] The behavior of the logarithm of the likelihood ratio  $\Lambda t(\theta)$  corresponding to the values of the parameter  $\theta$  and  $\theta + u b_t^{-1}$ , where  $u \in R$ , and  $b_t$  is a monotonically increasing function as  $t \rightarrow \infty$ , is investigated for a family of Markov processes depending upon the real parameter  $\theta \in \Theta \subset R$ . Conditions under which the family of such processes exhibits local asymptotic infinite divisibility are analyzed. The conditions of local asymptotic infinite divisibility, but are weaker than in other studies devoted to processes with discontinuous realizations. The findings are proved on the

basis of the theorem of the limiting distribution of the sum of stochastic integrals with respect to the continuous local Martingale and with respect to the local Martingale measure. A theorem and three lemmas are stated and proved. References 17: 16 Russian, 1 Western.  
[431-6900]

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UDC 681.323

PRINCIPLE OF MODELING ONE CLASS OF NONLINEAR DIFFERENTIAL EQUATIONS

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR SERIYA A. FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 4, Apr 85 (manuscript received 7 Mar 84) pp 60-62

BABICH, A. B., Institute of Civil Aviation Engineers, Kiev

[Abstract] The concept is investigated of organizing parallel multiprocessor computational structures based on applying the rule, properties and methods of differential  $T(dt)$ -transforms to the original mathematical model. A  $T$ -equation reduction method is proposed that makes it possible to parallel the computational process for determining the current sample, and to increase the output of systems used to model objects described by nonlinear differential equations of arbitrary order. An  $n$ th order nonlinear differential equation that describes a fairly wide group of physical and mathematical problems is examined. A parallel algorithm for a two-level multiprocessor computing structure is presented. It is estimated that for, e.g.,  $k=10$  samples in 10 integration intervals, a solution will be obtained 40 times more rapidly by the second of the algorithms presented than by the first. Figures 1; references: 2 Russian.  
[434-6900]

UDC 517.938

SETS OF INVARIANT TORI FOR LINEAR EXTENSIONS OF DYNAMIC SYSTEMS

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 8, Aug 85 (manuscript received 29 Jan 85) pp 15-19

SAMOYLENKO, A. M. and KULIK, V. L., corresponding member, UkSSR Academy of Sciences, Institute of Mathematics, UkSSR Academy of Sciences, Kiev

[Abstract] For stability analysis of an invariant toroidal surface containing the trajectories of quasi-periodic solutions to an autonomous system of differential equations in the theory of nonlinear multifrequency vibrations,

such a surface being describable by two systems of equations, a theorem is proved which pertains to an  $n \times n$ -dimensional symmetric matrix function with zero determinant at some point of that surface. The proof is based on a lemma with the two systems of equations assumed to have Green functions of that torus problem. It is further demonstrated that an appropriate modification of the corresponding  $n$ -dimensional vector function yields one equality with an integral on the right-hand side describing all nontrivial tori. A system of equations for a dynamic system linearly extended by perturbation is shown to have a countless number of invariant tori describable by one expression with the sum of two integrals on the right-hand side. References: 8 Russian. [18-2415]

# CHAOS IN SIMPLE EQUATIONS: DIFFERENCE, DIFFERENTIAL-DIFFERENCE AND PARTIAL DIFFERENTIAL ONES

Tbilisi DOKLADY in Russian Vol 18, 1984, presented 18 May 83

SHARKOVSKIY, A. N.

[Abstract] Simple equations whose solutions generate "chaos" such as real turbulence or "dry turbulence" are analyzed, specifically difference and differential-difference equations as well as partial differential ones, the purpose being to relate certain boundary-value problems for partial differential equations to difference and differential-difference equations. The simple system of equations  $u_1 - u_x = 0$ ,  $v_1 + v_x = 0$ ,  $\{0 \leq x \leq 1, i \geq 0\}$  with

boundary conditions  $H_1(u, v, u_1, v_1)_{x=a} = 0$ ,  $i=0, 1$ ,  $a_0=0$ ,  $a_1=1$  and initial

conditions  $u|_{t=0} = \alpha^1(x)$ ,  $v|_{t=0} = \beta(x)$  is considered as an example, with initial

and boundary conditions assumed to be matched. This problem is reduced to a system of differential-difference equations and the asymptotic behavior of its solutions at time  $t \rightarrow \infty$  is examined in the case where oscillations with increasing frequency are possible. The properties of such solutions are established by mapping and by determination of the limit functions which the solutions to difference and differential-difference equations approach.

A corresponding theory of perturbations, particularly singular perturbations as those associated with viscosity, is being now developed for an adequate description of physical models. Figures 3; references 9: 6 Russian, 3 Western.

[591-2415]

# MASLOV'S NONSTANDARD CHARACTERISTICS AND OPERATOR METHOD IN LINEAR PROBLEMS OF TRANSIENT WAVES ON WATER

Moscow FUNKTSIONAL'NYY ANALIZ I EGO PRILOZHENIYA in Russian Vol 19, No 4, Oct-Dec 85 (manuscript received 30 Apr 84) pp 43-54

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[Abstract] The V. P. Maslov operator method with nonstandard characteristics is applied to asymptotic solution of the system of differential equations describing waves on water. This system of three linear wave equations is formulated exactly, in dimensionless variables, for the velocity potential  $\phi(x, y, t)$  of a fluid on the bottom of a basin of infinite horizontal dimensions in the gravitational field. Two problems are solved for this system of equations, the Cauchy-Poisson problem and the Cerenkov problem of a point source moving along some curve in the plane of the initially quiescent free surface, each in the general case of a nonuniform basin depth and neither of them solvable in that case by the Fourier method. Their solution is based on Duhamel's principle, in accordance with which a pseudodifferential operator corresponding to the initial conditions for the first problem is sufficient for solving both, as well as on an existence and uniqueness lemma which also reduces that system of wave equations to a single ordinary differential one referred to the free surface. Nonstandard characteristics are then introduced which determine the solutions to both problems, these characteristics being describable in terms of derivatives of Hamiltonians  $H^\pm(x, p, \omega)$  with respect to  $p$  and  $x$ . At  $|p| \gg 1$  these two Hamiltonians correspond to the Hamilton-Jacobi equations obtained during solution of the original system of wave equations by the Wentzel-Kramers-Brillouin method. Three theorems are stated and proved which validate the solutions to both problems, the first one for  $f = 0$  and the second one for  $f = h^2 f_0$  in the third wave equation  $h^2 \phi_{tt} + \phi_y = f(x, t)$  at  $y = 0$ , and the third one for the analog of Kelvin's wedge. The third wave equation is then modified to  $h^2 \phi_{tt} + (1 - \mu h^2 \nabla^2) \phi_y = 0$  at  $y = 0$ , including surface tension in  $\mu = kg/\rho V^4$  ( $k$  - coefficient of surface tension,  $\rho$  - density of fluid,  $V$  - velocity of point source,  $g$  - gravitational acceleration), for determination of the critical velocity of the point source above which the latter will and below which it will not emit waves. For deep water this critical velocity is found to be approximately 1 km/h. The authors thank L. A. Bagirov, V. G. Danilov and R. V. Isakov for helpful discussions. Figures 1; references 18: 15 Russian, 3 Western. [67-2415]

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